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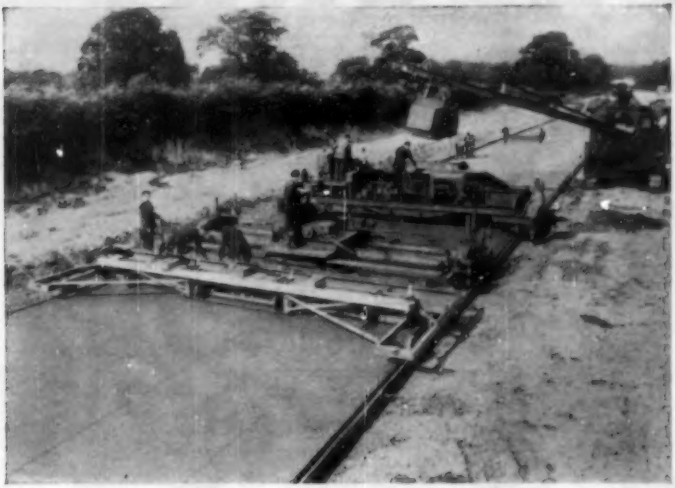

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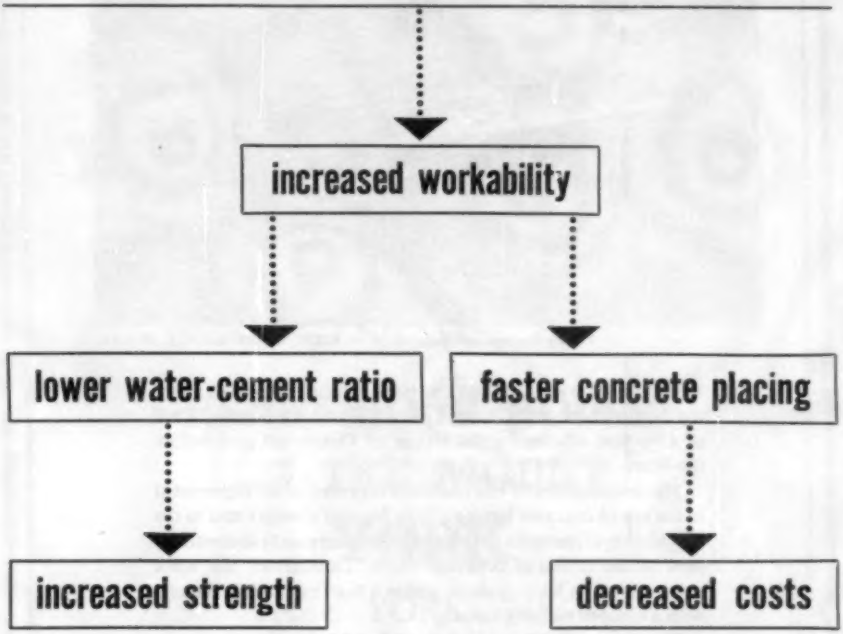


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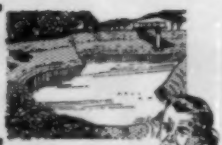

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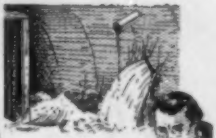

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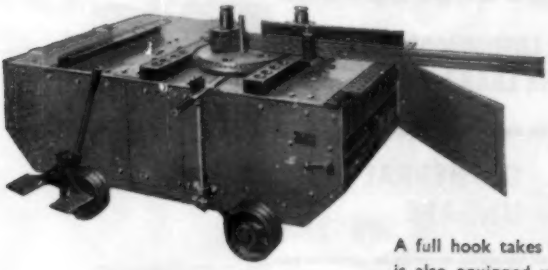

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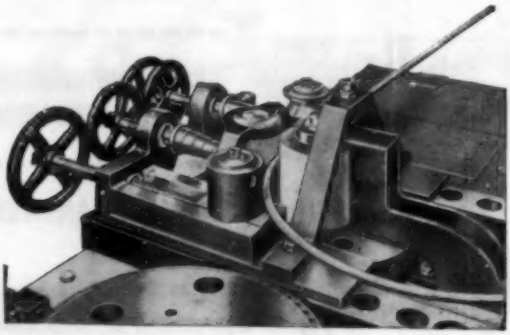

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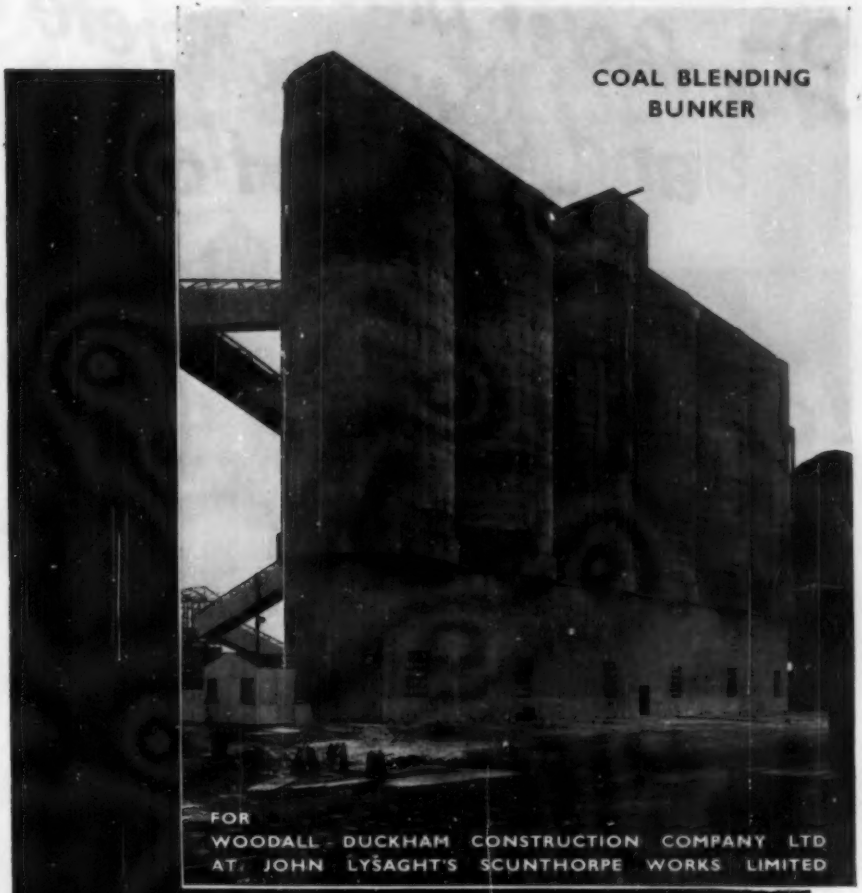


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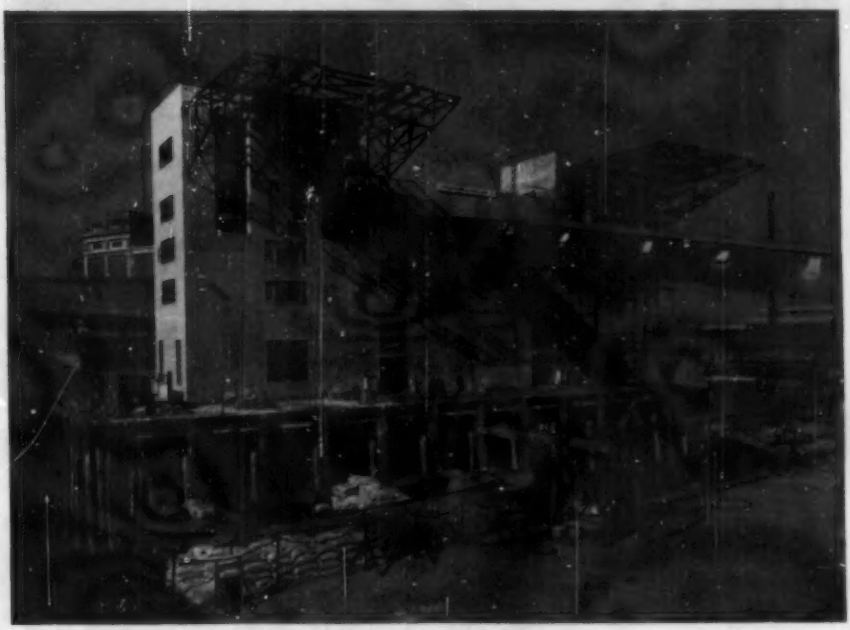

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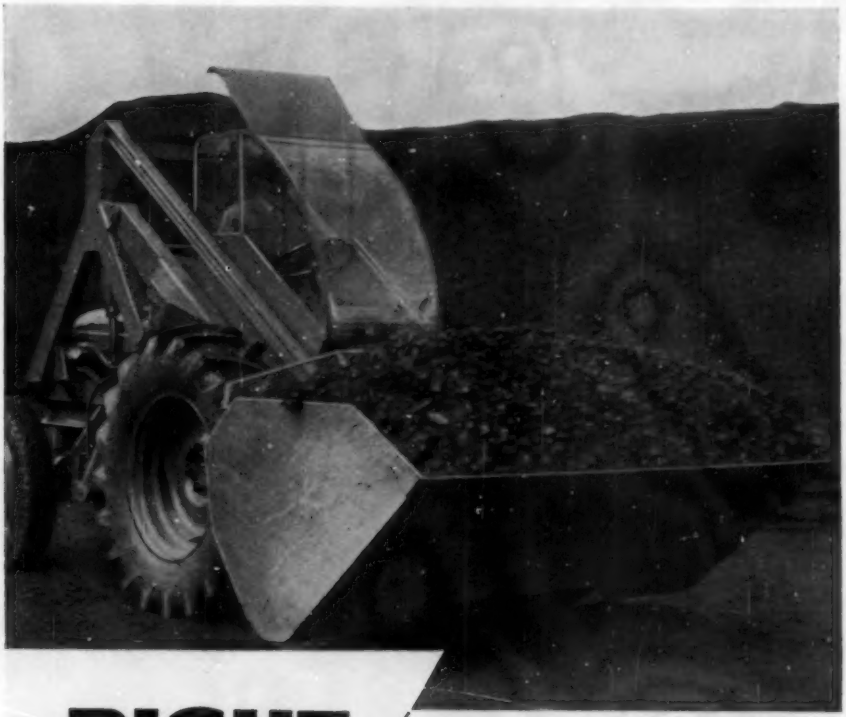

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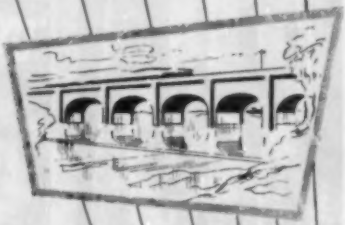

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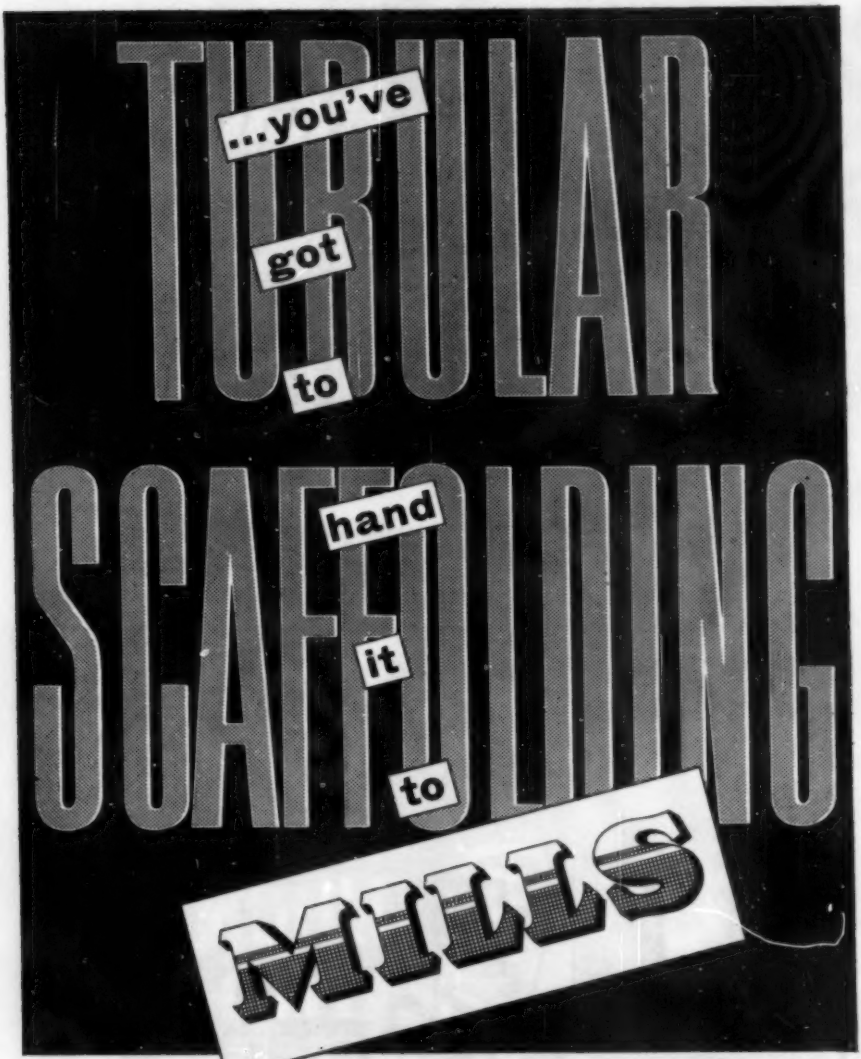


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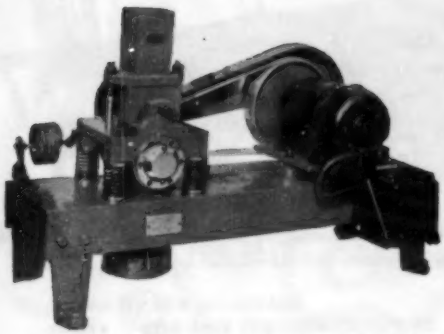

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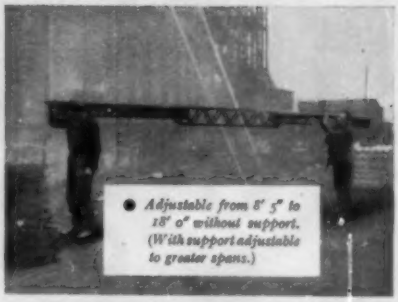

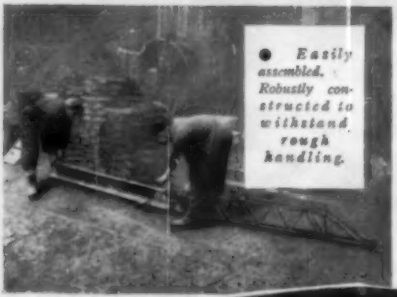


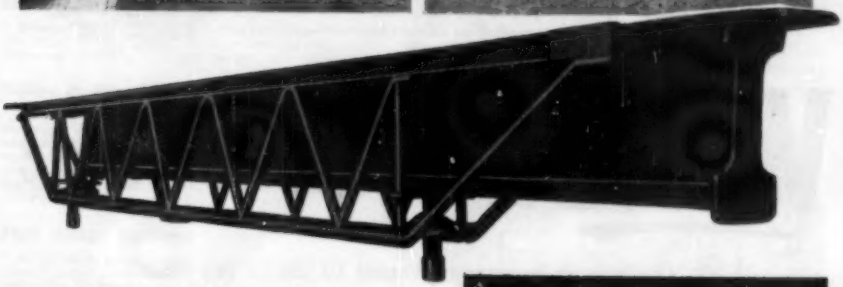

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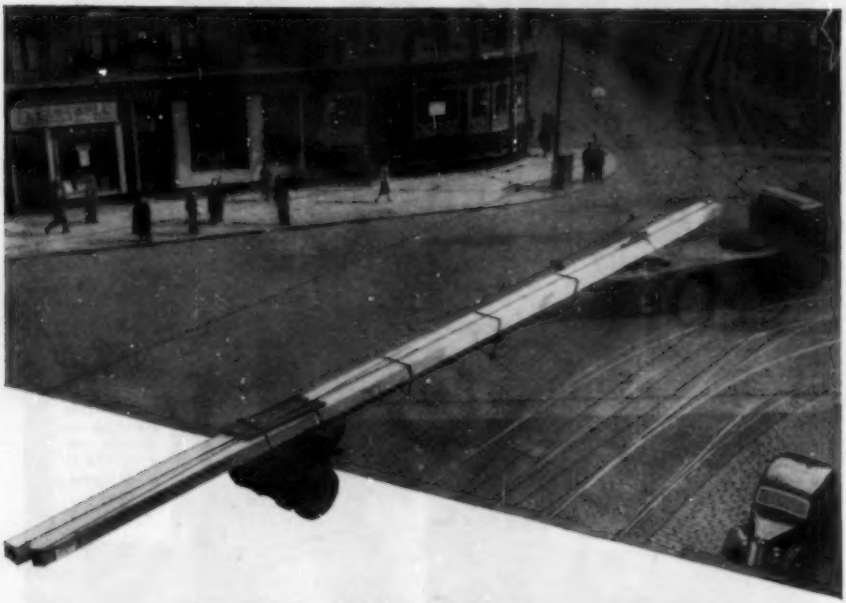

. . . for use in manufacturing this 85ft. prestressed concrete pile, shown passing through Glasgow on its way to the docks. It will be used in the construction of the new quay walls at the shipyards of the Fairfield Shipbuilding & Engineering Co. Ltd., Govan, Glasgow.

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Messrs. Babtie, Shaw & Morton, Chartered Civil Engineers, 17 Blythswood Square, Glasgow C.2.

# WIRE for prestressed concrete

Our wire is in constant demand for use in important constructional undertakings, at home and overseas. We were among the first producers of wire designed for prestressed concrete work.

BRITISH ROPES LIMITED. HEAD OFFICE. DONCASTER TELEPHONE: DONCASTER 4010

## Most important advance so far in portable compressor design

# NO CLUTCH, PISTONS, OR VALVES MEAN VIRTUAL ELIMINATION OF BREAKDOWNS

**Operators welcome centralised control panel and other new features of CP "Power Vane" Rotary Compressors.**

Announced as the most important advance in portable compressor design to date, the Consolidated Pneumatic range of "Power Vane" units removes almost completely the cost and inconvenience of frequent breakdowns and servicing by eliminating those parts which commonly cause trouble in any compressor of conventional design. The compressor is a simple two-stage vane type rotary into which is injected copious quantities of oil, for internal cooling, lubrication and sealing. This revolutionary design gives many striking advantages.

### Lower maintenance costs

There is no clutch, pistons, valves or crankshaft. The moving parts are flooded in oil and wear is reduced to an absolute minimum. The entire unit is designed for simplicity and economy.

### Compactness

The Rotary can be driven at higher rotational speeds than the conventional type of compressor of similar output. The engine and compressor are therefore smaller and more compact. Saving in bulk is approximately 30%.

### Lightness

The reduced dimensions of the compressor and engine mean a great saving in weight.

### Smooth operation

Because there is no reciprocating motion in the Rotary, it is free from vibration and the air is delivered smoothly and not in pressure pulses.

### Safety devices

Provided with fully automatic devices to stop the plant in the event of oil pressure failure or excessive rise in temperature, the Rotary is virtually foolproof. No damage can be caused by mishaps or negligence such as clogged filters, lack of oil or engine coolant, oil or coolant pump failure, etc.

### New design features

All controls are assembled on one conveniently placed panel. Non-detachable radiator doors are adjustable to compensate for weather variations. Side closing panels are simply raised out of the way without awkward detaching. Two-wheel models have built-in compartments for housing tools, etc.

Model 385-RO-2

### AVAILABLE IN FIVE SIZES

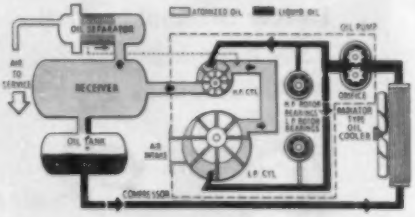
Model 600-RO-2, powered by Rolls-Royce oil engine, is a "ten-tool" unit ideal for big construction schemes.

Model 385-RO-2, powered by Rolls-Royce, is a "seven-tool" plant of ample margin for average construction needs.

Model 210-RO-2 is a medium capacity plant suitable for "four-tool" operation.

Model 175-RO-2 is suitable for "three-tool" operation yet is rendered highly mobile by its two-wheel mounting.

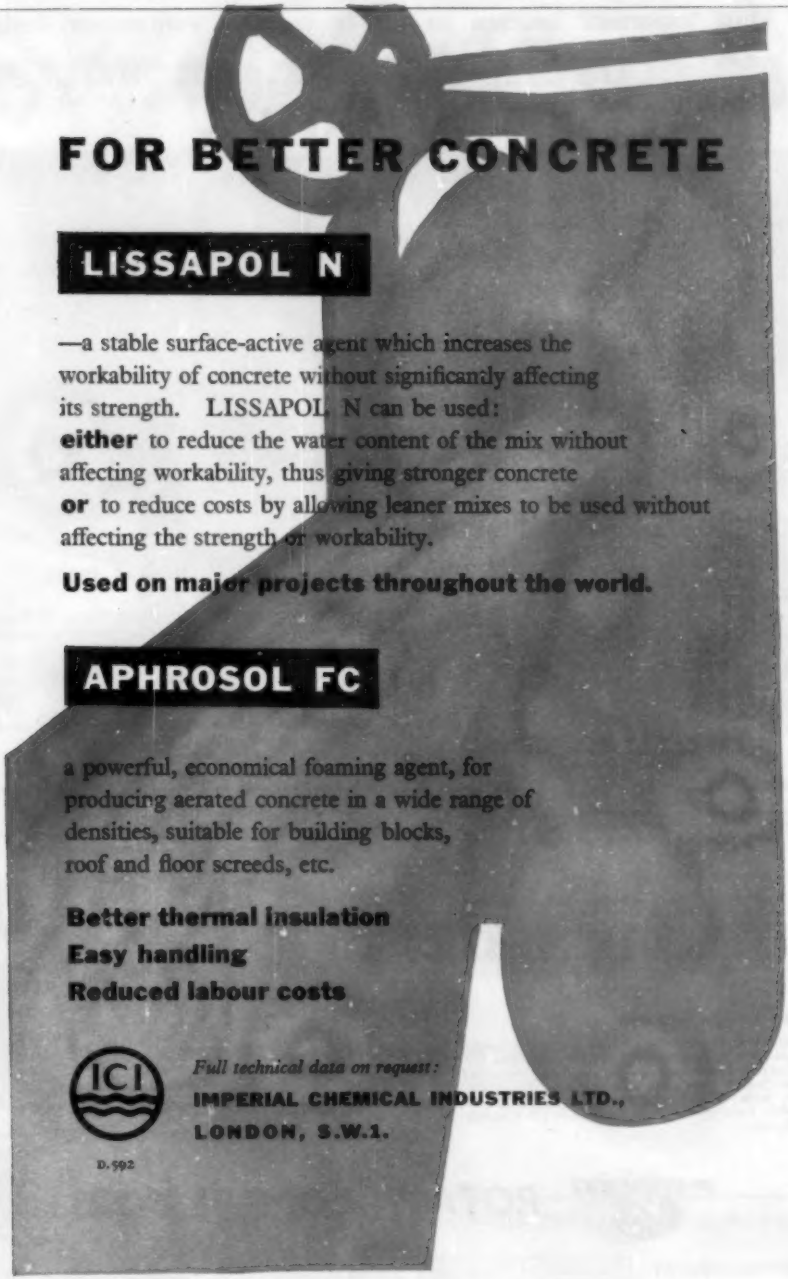
Model 120-RO-2 gives the maximum output of any "two-tool" plant and is of ample size for operating two breakers or rock drills.




*Diagrammatic explanation of the Power Vane Rotary Compressor*

POWER VANE ROTARY COMPRESSORS

MANUFACTURED BY Consolidated Pneumatic TOOL CO. LTD., 232 DAWES ROAD, LONDON, S.W.6



# FOR BETTER CONCRETE

## LISSAPOL N

—a stable surface-active agent which increases the workability of concrete without significantly affecting its strength. LISSAPOL N can be used:
**either** to reduce the water content of the mix without affecting workability, thus giving stronger concrete
**or** to reduce costs by allowing leaner mixes to be used without affecting the strength or workability.

**Used on major projects throughout the world.**

## APHROSOL FC

a powerful, economical foaming agent, for producing aerated concrete in a wide range of densities, suitable for building blocks, roof and floor screeds, etc.

**Better thermal insulation**
**Easy handling**
**Reduced labour costs**

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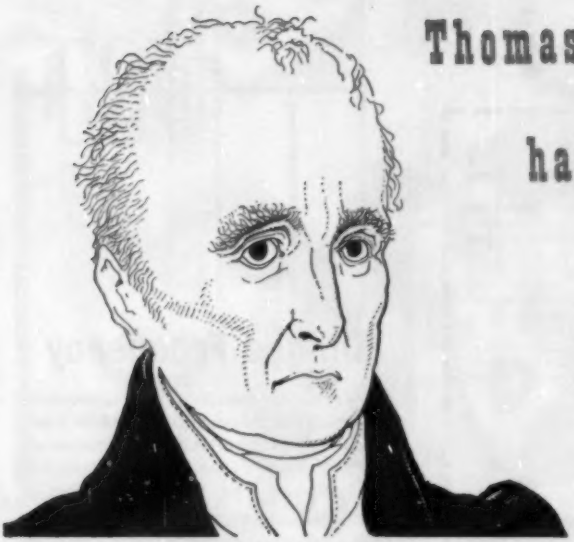
*Full technical data on request:*
**IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1.**

D.592

**HISTORICAL HYPOTHESIS NUMBER 3**



**Thomas Telford had arterial trouble of course**

***...being*** *faced with the problem of building roads to cope with the faster and heavier traffic of the 19th century.*

*How glad he would have been to use present day concrete cured with SISALKRAFT Blankets. Their toughness and ease of handling simplify and speed up road making; a safeguard against winter frosts and assured curing in summer heat.*

*He would have marvelled, too, at the strength of Subsoil grade SISALKRAFT which takes such good care of the underside of concrete, reducing sub-grade friction, ensuring maximum strength and protection from impurities.*

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*Estd. 1857*

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Sole Distributors for British Sisalkraft Ltd. *Phone:* HOLborn 6949 (20 lines) *Grams:* Brickwork, Estrand, London

# Underpinning by Pynford

1 Pynford Beams have been constructed at all levels, when forming lintels, etc., and during the repair or extension of existing foundations.

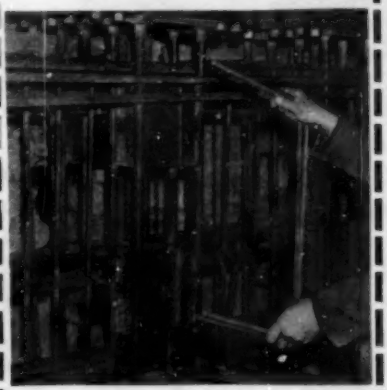
2 Pynford offer a ***Complete Foundation Service*** including ***Site Investigations, Foundation Design and Construction, Underpinning and Jacking.***

3 Pynford Jacking, based on entirely new principles, is a solution to the problems of Mining Subsidence and Clay Shrinkage.

4 A new range of jacks which are controlled by moving water levels enables the distortion caused by settlement to be corrected swiftly and cheaply.

5 Write for free illustrated brochure.

*Illustration shows a steel stool acting as shear reinforcement in a Pynford Beam.*



**Pynford Limited**

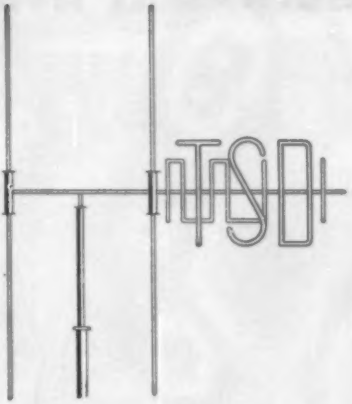
*Patentees*

***Foundation Engineers, Site Investigations, Underpinning, Jacking***

**74 LANCASTER ROAD, STROUD GREEN LONDON, N.4**

*Telephone :* ARChway 6216/7





# Unique Frequency

As a company specialising in the development and manufacture of sealing compounds for joints, EXPANDITE Limited are unique. Consequently they have amassed considerable information in this field which is not common knowledge.

The Expandite Technical Service Department provides a consultancy service which is available to all who care to ask. The Department is constantly dealing with the many and varied problems posed by Government Departments, Local Authorities, Civil Engineers, Architects and Industrial Organizations.

The advice is given free and incurs no obligation. The Technical Service Department is there to help you with *your* sealing problems. It will provide the best advice and ensure only the right materials are used to the best effect.

## "Joints in Concrete Structures"

This is the title of an informative and useful 16-page paper published by Expandite Limited. A copy will be forwarded on request.

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**ASSOCIATES AND DISTRIBUTORS THROUGHOUT THE WORLD**

*Flats in Reinforced Concrete for the L.C.C. at Clarence Avenue, Clapham Park, London*

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The most successful building operations today are the fruits of collaboration—the closest possible partnership of owner, architect and a widely experienced firm of builders and contractors. Wates are such a firm.

Wates believe in pre-planning, the scrupulous examination of all possible means of achieving the client's aims with maximum economy and at maximum speed. And the final drawings are those which crystallize optimum solutions to every aspect of the building problem. The Wates method invests the owner with complete control of costs: he gets his building at a price within his budget, and he gets it on time.

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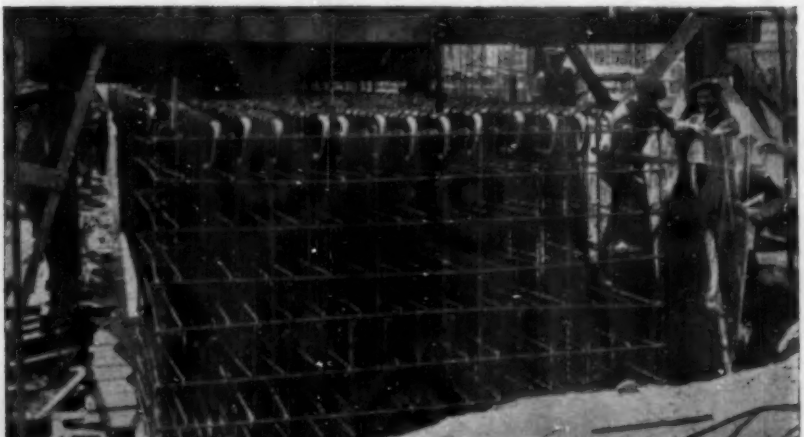
# WHITEHEAD'S
## REINFORCING
# BARS



# have been regularly used by leading Contractors for reinforced concrete work since 1903

We were the pioneers in the supply of steel bars for reinforced concrete work and have given to the industry over 50 years of unbroken service, unequalled for quality and dependability. Contracts on which WHITEHEAD STEEL have been used include some of the largest and most important in the country.

We can supply bars bent to shape, hooked, etc., in accordance with Contractors' requirements, at reasonable charges.

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NEWPORT Tel. No. NEWPORT 45401 (P.B.X.) MON.

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BIRMINGHAM OFFICE: King Edward House, New Street, 2. Telephone: Midland 0412–3.
MANCHESTER OFFICE: Chronicle Buildings. Telephone: Blackfriars 3172.
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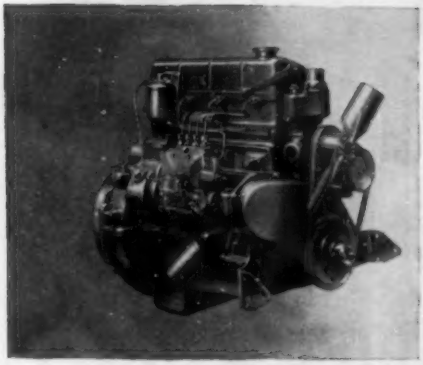
# POWER

## DIESEL INDUSTRIAL ENGINES



### 954E SERIES

BORE M.M. 100 · STROKE M.M. 115
NO. OF CYLINDERS 4
COMPRESSION RATIO 16:1
SWEPT VOLUME 3·61 LTRS. · CYCLES 4
ENGINE HEIGHT 32·62 INS.
ENGINE WIDTH 23·6 INS.
ENGINE LENGTH 33·83 INS.

| B.H.P. | R.P.M. | | | | | |
|---|---|---|---|---|---|---|
| | 1000 | 1200 | 1500 | 1600 | 1700 | 1800 |
| 1 HOUR RATE | 26·5 | 32·0 | 38·5 | 40·5 | 42·0 | 43·0 |
| 12 HOUR RATE | 23·0 | 28·0 | 34·0 | 35·75 | 37·0 | 38·0 |
| 24 HOUR RATE | 21·0 | 25·6 | 31·0 | 32·5 | 33·6 | 34·5 |

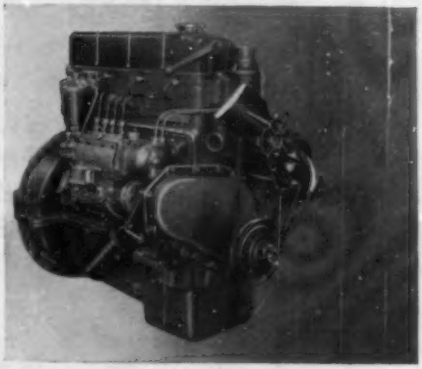
*Conforming to the requirements of BSS.649/49*

### 563E SERIES

BORE M.M. 100 · STROKE M.M. 115
NO. OF CYLINDERS 4
COMPRESSION RATIO 16:1
SWEPT VOLUME 3·61 LTRS. · CYCLES 4
ENGINE HEIGHT 34·5 INS.
ENGINE WIDTH 26·88 INS.
ENGINE LENGTH 31·20 INS.

| B.H.P. | R.P.M. | | | | | |
|---|---|---|---|---|---|---|
| | 1250 | 1500 | 1800 | 2000 | 2250 | 2400 |
| 1 HOUR RATE | 34·75 | 41·5 | 50·0 | 54·5 | 58·0 | 59·0 |
| 12 HOUR RATE | 31·0 | 37·5 | 44·5 | 49·0 | 52·5 | — |
| 24 HOUR RATE | 27·8 | 33·2 | 40·0 | 43·6 | 46·5 | — |

*Conforming to the requirements of BSS.649/49*



**STANDARD EQUIPMENT** Starter Motor (mechanically engaged Bendix pinion), Generator (12 Volts), Injector Pump and Injectors, Fuel and Oil Filters, Fuel and Water Pumps, Thermostat, Pneumatic or Mechanical Governor, Fan and Fan Belt, Decompressor.

**OPTIONAL EQUIPMENT** Engines can also be supplied with Solenoid Axial Starters and Industrial Flywheels for hand starting, together with many other accessories including Hour Meters, reverse flow fans etc. . . . in line with special requirements.

**These two Industrial Engines offer Diesel advantages at remarkably low cost and are, of course, backed by the well known Ford Dealer Service both in this country and throughout the World.**

*Full details of the above engines obtainable from:—* **INDUSTRIAL UNIT SALES DEPARTMENT**

**FORD MOTOR COMPANY LIMITED · DAGENHAM · ENGLAND**

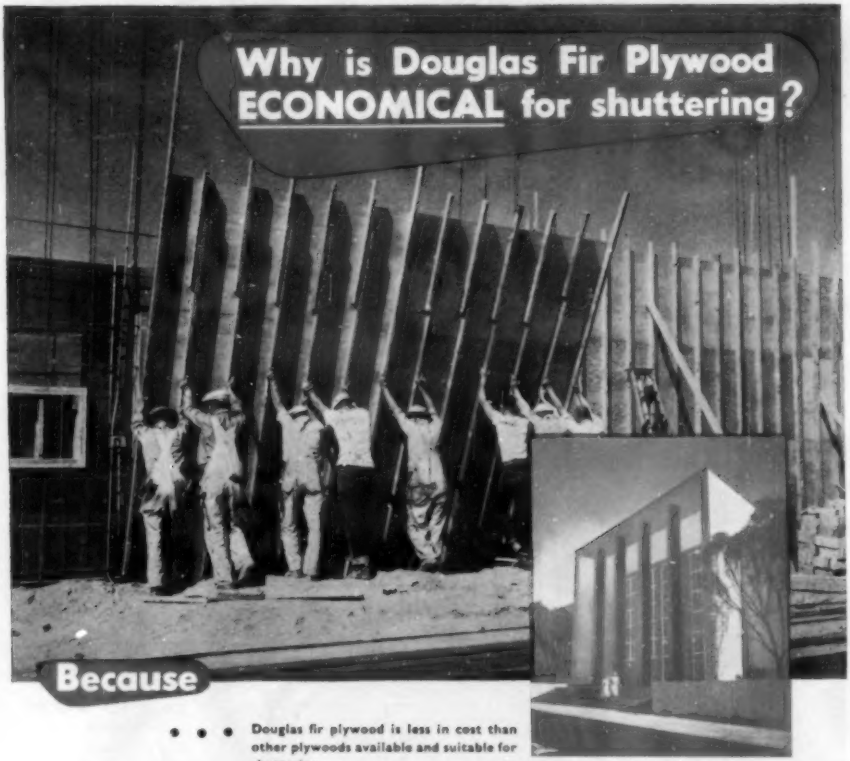
# CONCRETE PILING LIMITED

250,000 gallons capacity reinforced concrete Water Tower constructed for the Royal Borough of Tunbridge Wells

*Borough Surveyor and Water Engineer :*
H. P. Bishop, M.I.C.E.

*Consulting Engineers :*
Indented Bar & Concrete Engineering Co. Ltd.

10 WESTMINSTER PALACE GARDENS
ARTILLERY ROW, LONDON S.W.1.
*Telephone :* ABBEY 1626/7




• • • Douglas fir plywood is less in cost than other plywoods available and suitable for shuttering.

Because Douglas fir plywood has a unique combination of properties which are fully utilized when forming concrete. The large smooth panels are easily handled. Thirty-two square-foot panels mean fewer joins, less cutting and minimum waste . . . qualities which produce real savings in time and labour. Concrete poured in Douglas fir plywood forms requires very little finishing because ridge and join marks are greatly reduced. Permanent plywood forms can be quickly and easily cleaned, stored and transported—and with reasonable care, may be re-used 40 times or more.

*Worth investigating!*

. . . the new economy grade plywood that is priced to reduce the cost of concrete work by pounds !—Ask your usual supplier about DOUGLAS FIR UNDERLAY SHEATHING. (Many other grades available.)

PHENOLIC BOND WATERPROOF WEATHERPROOF BOIL TESTED

SEABOARD CANADIAN DOUGLAS FIR PLYWOOD

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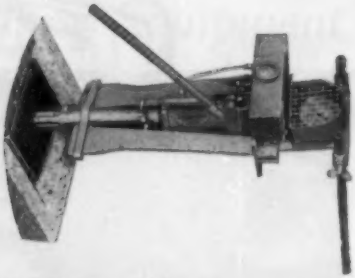
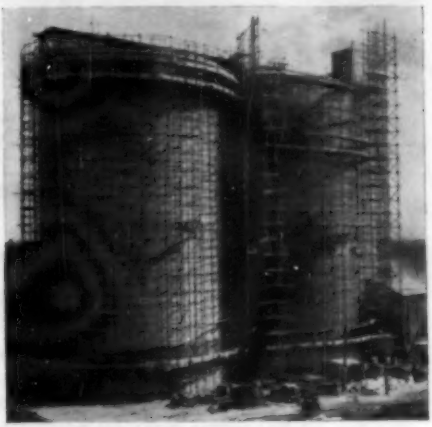
# GIFFORD-UDALL



# PRESTRESSING SYSTEM

## was used for the construction of these silos



Prestressed concrete silos erected by John Laing & Son, Ltd., for the British Sugar Corporation at York. These silos are about 100 ft. high with a diameter of 66 ft.

The advantages of the Gifford-Udall-CCL prestressing system are :

FOR THE CONTRACTOR : Speed and simplicity of operation. Light, compact and sturdy equipment. Positive mechanical CCL anchorage. Inexpensive equipment. The backing of the CCL service.

FOR THE DESIGNER : Flexibility of design concerning all forms of construction. The obvious design advantages of a single-wire system combined with positive and inexpensive mechanical anchorage.

## CABLE COVERS LTD

**PRESTRESSED CONCRETE DIVISION**

**ST. STEPHEN'S HOUSE WESTMINSTER S.W.1**

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**ENDORSED BY FAMOUS BUILDING CONTRACTORS**

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You need no props ! Bolt up your formwork to Rawlhangers slung over the beams, and the job is firm and secure, ready for pouring ! Below, instead of props, you have clear, unobstructed working space. Rawlhangers save you time, timber and money, whether you are laying solid concrete floors or partially cladding beams for precast floors. Write for free copy of ' *Lower the cost of raising the shuttering* '— a handsome technical brochure on the many time-saving uses of Rawlhangers, Rawlties and Rawloops.

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THE WORLD'S LARGEST MANUFACTURERS OF FIXING DEVICES

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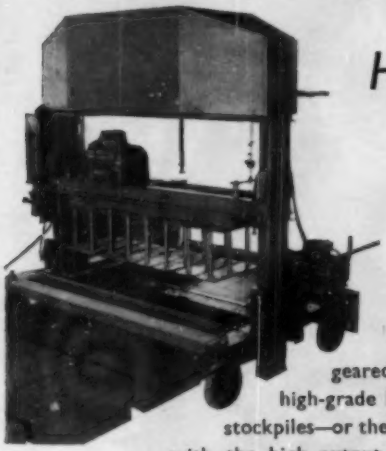
# 'MULTIBLOC'



## *Handling Equipment*

## SPEEDS 'THROUGH PUT' and LOADING of BLOCKS

The 'Multibloc' Handling System covers all stages in the manufacture of building blocks from mixing the materials. It is geared to handle the mixed concrete, produce high-grade blocks, and finally dispose of the blocks to stockpiles—or thence to lorries—in an even flow commensurate with the high output of the main unit, the 'Multibloc' Mobile Block-making Machine. There is no breaking of bulk. Mass-produced, the blocks are mass-handled in units of increasing size. This means an enormous saving of labour; four men can remove, stack and load sixty rows of finished blocks in one hour, i.e. as fast as two men on the 'Multibloc' machine are making them.

Types of block that are made without pallets

WELL CAVITY

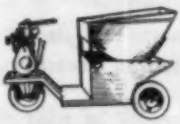
THROUGH CAVITY

TONGUED & GROOVED

BRICK

INFILLER BLOCKS & SPECIAL SHAPES

### FLEXIBLE SYSTEM SIMPLIFIES HANDLING



**'MULTIBLOC' Aggregate Feed Truck £154**

**'MULTIBLOC' Patent Lift Truck £54**

**'MULTIBLOC' Carrier Truck £340**

**'MULTIBLOC' Patent Grab £220**

A large range of alternative equipments can be supplied with the 'Multibloc' for producing B.S. and other types of blocks. Prices from £935, according to equipment supplied.

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*Sole Concessionaires for the British Isles*

**ALAN R DAVIES of BRISTOL**

CONTRACTORS' and QUARRY PLANT

*Tel.: 39418/9 Grams: 'Alanar,' Bristol*

The PC3 Electrically Driven Concrete Pump—20/24 cu. yds. per hour.
Smaller PC4—8/10 cu. yds. per hour.
Range up to 135 ft. vertical or 1,500 ft. horizontal.

**FOR SALE AND HIRE**

*EFFICIENT RECONDITIONING SERVICE*

# CONCRETE BY PUMP AND PIPELINE

- The latest and most efficient method of placing concrete.
- Life of Pump practically indefinite : all essential surfaces in contact with concrete are renewable.
- Pumpable concrete must of necessity be good concrete.
- Pump and Mixing Plant can be located at the most convenient position within the pumping range.
- The continuous output of the Pump at a constant speed governs the working of the whole concreting gang.

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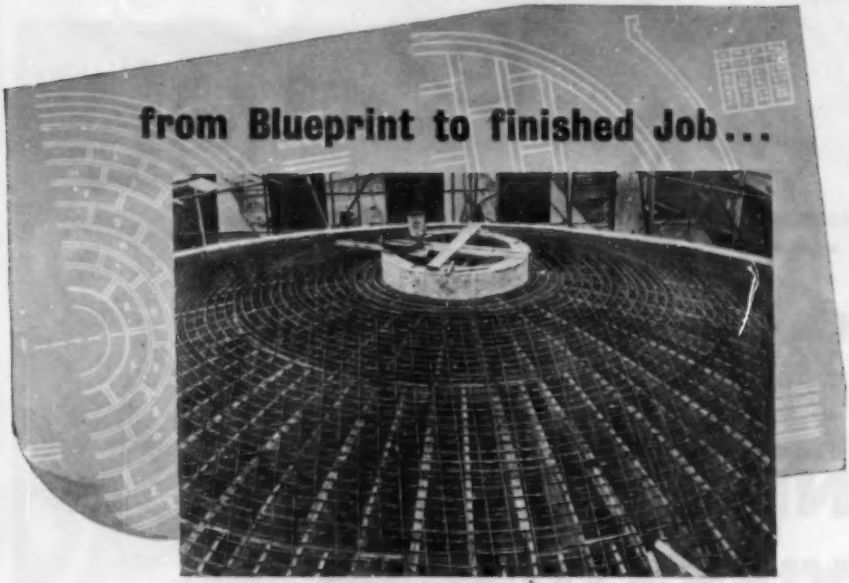


# A complete concrete reinforcement service

The large range of "Expamet" Reinforcements provide a wide choice to suit all types of concrete construction. There are more than 100 standard variations and weights in "Expamet" Reinforcements from under 2 lb. to over 30 lb. per square yard.

***Expanded Steel and Welded Fabric***

"Expamet" Expanded Steel Sheet Reinforcement; "Expamet" Welded Fabric; Super "Ribmet" and other specialist materials can be adapted to meet reinforcement problems of all kinds, from solid slab decking and hollow floors, to light shell construction such as barrel vault and dome roofs. They are just as effective reinforcing concrete in precast units as in sea defence works. "Expamet" can be of assistance to you. Write or telephone, we shall be pleased to advise in the choice and use of "Expamet" Reinforcements for any job you have in mind.

**Dome at Barclays Bank, Exeter;** showing "Expamet" Welded Fabric reinforcement and "Ribmet" permanent centering. *Engineers:* J. F. Farquharson & Partners, London, W.1. *Contractors:* J. Garrett & Sons Ltd., Plymouth.

*Thickness of the concrete shell is 2¾ ins., thickening out to 5 ins., at a distance of 3 ft. 6 ins., from the periphery, plus a 2 in. screed of light concrete. The dome is supported by a reinforced concrete ring-beam on columns, and has a diameter of 39 ft. 6 ins., a rise of 5 ft. 2¾ ins., and a 40 ft. radius of curve. A 5 ft. diameter central dome light is fitted.*

## 5-part concrete reinforcement service

1. Design with Economy.
2. Preparation of working drawings.
3. Supply of Reinforcements (Expanded Steel, Welded Fabric, Super Ribmet).
4. Delivery on schedule.
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This one-inch head pneumatic immersion vibrator solves all problems in obtaining efficient vibration of thin concrete members and concrete which is congested with reinforcement or prestressing wire. The vibrator will give equal satisfaction for general concrete work, as the 1" dia. head can be interchanged in a few minutes for a more powerful 1½" or 2½" dia. head. The weight of the type AS 30 is only 15 lb. and its frequency is 12,000 r.p.m.

# NEEDLE VIBRATOR

## with one-inch diameter head for concrete which is congested with reinforcement or prestressing wire

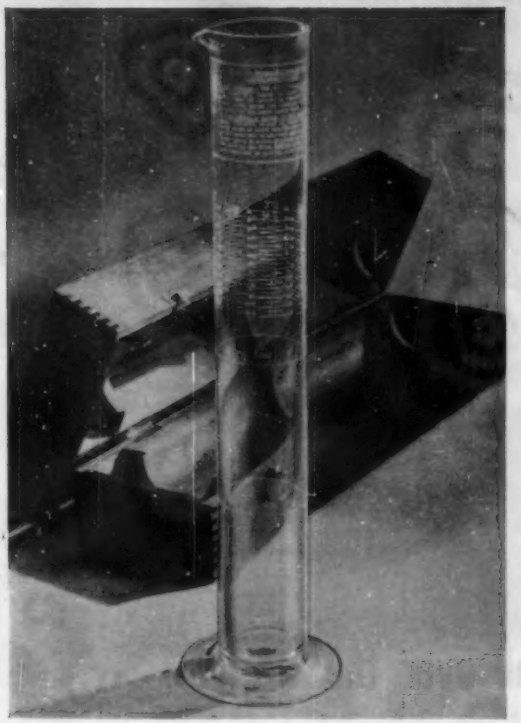
*Our range of immersion vibrators also includes the Giant pneumatic vibrator with a 4-in. head, the General-Purpose pneumatic vibrator with a 2¾-in. head, and the Lightweight electric vibrator with heads ranging from 1½ in. to 3 in. diameters, which is also available with petrol engine.*

**COMPACTORS ENGINEERING LTD.**

65 EFFRA ROAD, LONDON, S.W.2

*TELEPHONE: BRIXTON 4081-3*

# THE GAMMON-MORGAN WATER-IN-SAND ESTIMATOR



## ACCURATE
## SIMPLE
## RAPID

### measuring of WATER CONTENT IN SAND

The most accurate, simple, and rapid means of measuring the water content in the sand. No weighing or chemicals are required, and an adequate sample is used. The GAMMON-MORGAN WATER-IN-SAND ESTIMATOR should be available alongside every mixer, so that the water content of every mix may be correctly gauged. Full details will be sent on request.

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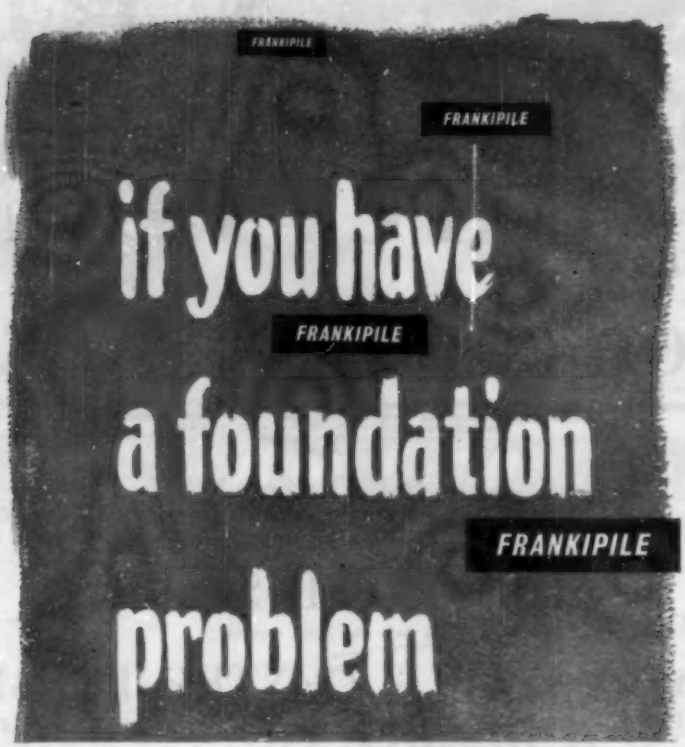


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# It's called a Channelizer

McCalls "MATOBAR" Fabric was used in this traffic "Channelizer" constructed for the Montreal City Planning Department. The junction is at Pie IX Boulevard and Sherbrooke Street East, Montreal P.Q.

*Photograph by courtesy of "The Gazette"— Montreal*

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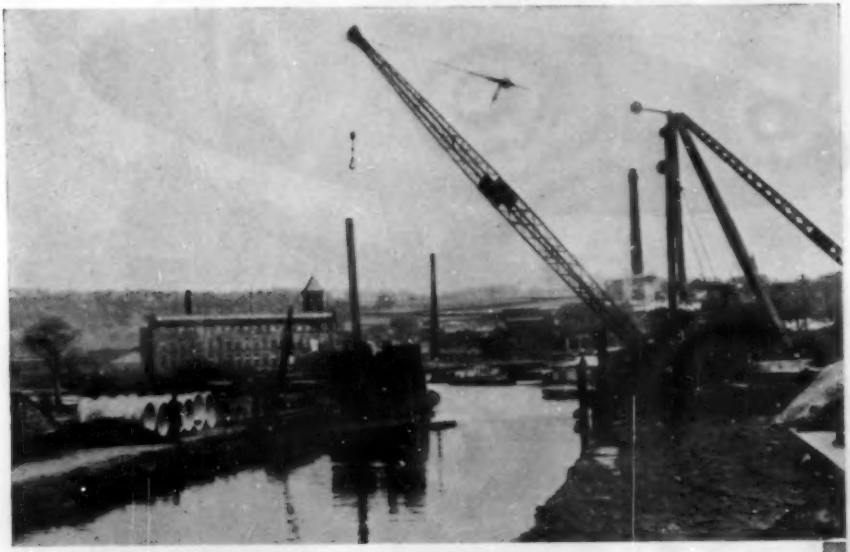

## A sewer laid beneath a canal in 5 days

*Illustration by courtesy of S. G. Wardley, B.Sc., A.M.I.C.E., M.I.Mun.E., City Engineer & Surveyor to the City of Bradford.*

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At a Whitsun week-end the Leeds and Liverpool Canal was drained, the central section was excavated, a sewer was laid, the canal bed, walls and banks were reinstated and the canal was refilled. The whole operation was completed in five days and about 60 cubic yards of Ciment Fondu concrete were laid.

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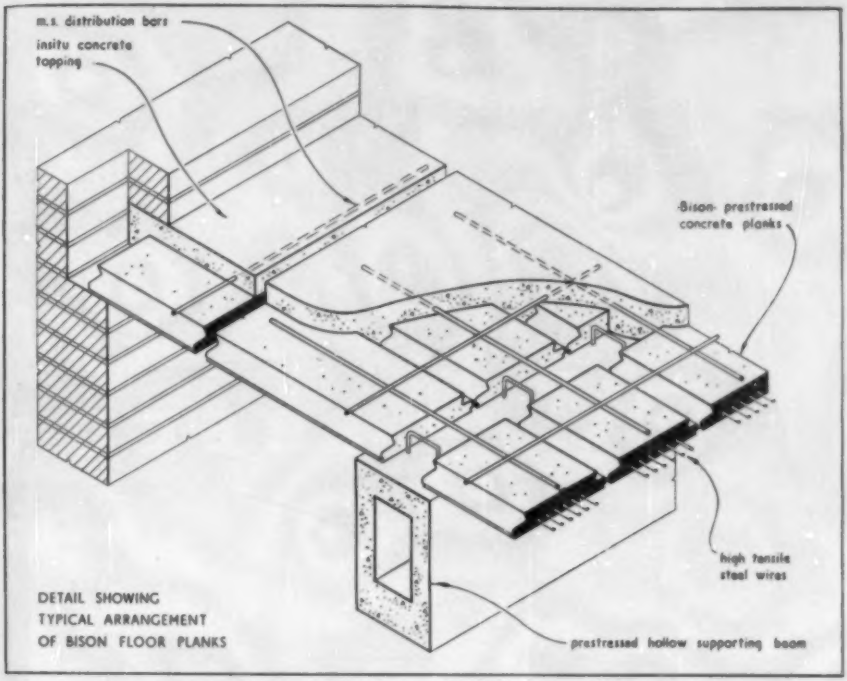


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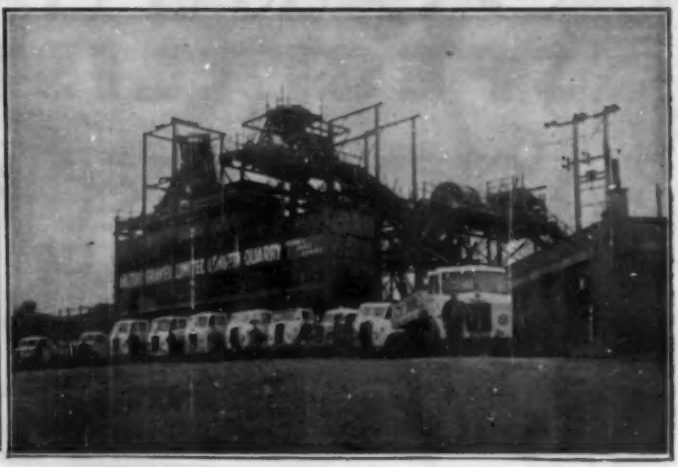

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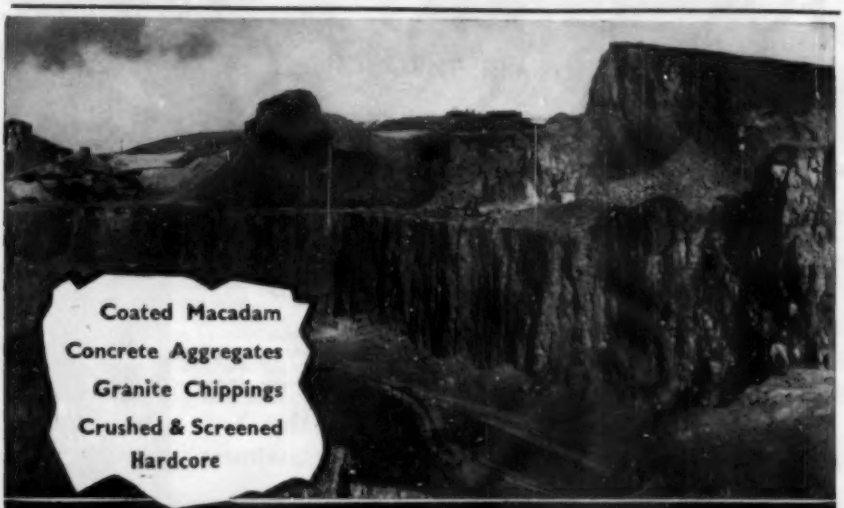


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THE 600 GROUP

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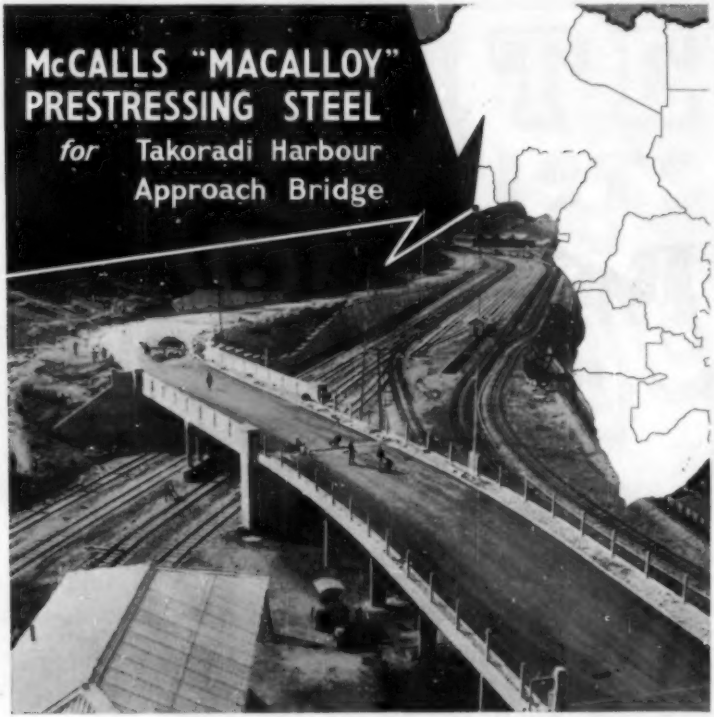


The photograph shows a prestressed concrete road bridge over the railway yard at Takoradi Harbour extensions, Gold Coast Colony. Designed by Rendel, Palmer and Tritton, Consulting Engineers to the Gold Coast Railways and Harbours Administration, and making use of the Lee-McCall system, the bridge was constructed by Taylor Woodrow (West Africa) Ltd. The precast beams of the bridge are of 44 ft. span, each prestressed with 3–$1\frac{1}{8}$" diameter Macalloy post-tensioned bars.

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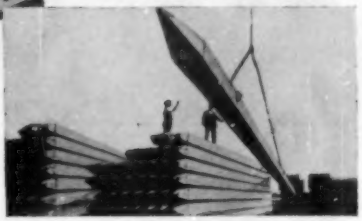

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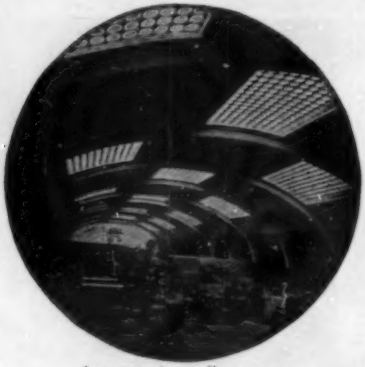

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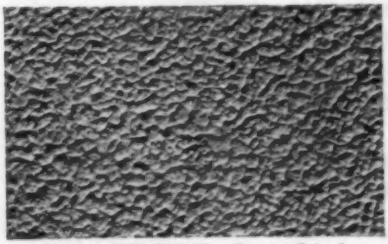

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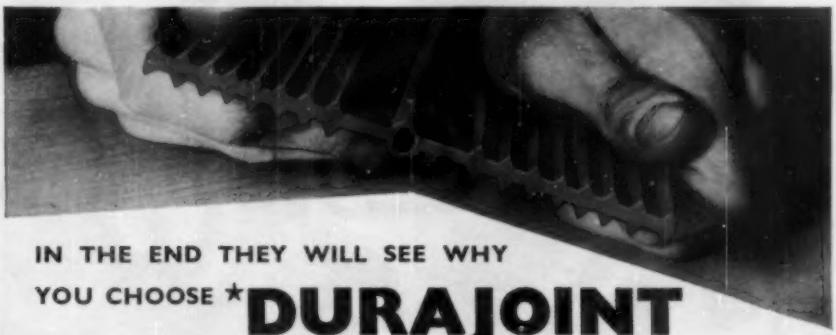

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# CONCRETE AND CONSTRUCTIONAL ENGINEERING

INCLUDING PRESTRESSED CONCRETE

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# EDITORIAL NOTES

## Technology in the U.S.S.R.

A VOLUME entitled " Soviet Professional Manpower ", issued jointly by the U.S.A. Engineering Manpower Commission of Engineers Joint Council and the U.S.A. Scientific Manpower Commission, is a study of the educational system of the Soviet Union in relation to the training of scientists and engineers, and is of particular interest at a time when the need for more scientific workers and technologists is becoming serious in Great Britain and in all other industrial countries. It appears that from the first days of the Russian revolution the fostering of training in the sciences and engineering has been a central purpose of the Russian State. This is based on a realisation of the role of technology in economic and political power, and the emphasis appears from this report to be on the needs and desires of the State rather than of the individual. In the early years of the Soviet Republics attempts were made greatly to increase the number of young people from the working classes entering higher education. By 1931, however, wishful thinking had to give way to an acceptance of the great truth that men are not all born equal and that they do not all have equal natural abilities, and since then the ability of the student rather than the humbleness of his origin has been the criterion in selecting students for higher education.

The importance attached to science and technology is shown by the fact that in the elementary classes of the U.S.S.R. 28 per cent. of the subjects are concerned with science ; in the intermediate classes more than one-third of the students' time is spent on scientific subjects, and in the secondary schools more than 40 per cent. of the time is spent on science and mathematics. As a result all the students leaving the higher schools have had substantial training in physics, chemistry, mathematics, and science, and the ablest pupils are later guided into technology. Much attention is being paid to the training of teachers ; in 1940 there were 28 students per teacher, but by 1950 the number had been reduced to 23.

In Russia there are about 1500 " technicums " which give a type of instruction generally above the high-school level but not aiming at professional competence in the sense of engineering schools in some other countries. Formerly, admission into the technicums was generally at the end of seven years of elementary education, and the technical courses were for a period of four years. More recently, however, there has been a more strict selection of those admitted, and it seems probable that future entrants will be selected largely from those who have had a

full secondary education. The training comprises theory and periods of practical experience in industry. The rate of graduation has recently been about 60,000 a year in engineering alone.

In higher education, the same trends are apparent. There are about 177 institutes for technological training associated with technical schools, in addition to the scientific training given in the thirty-three Soviet universities which are similar to European universities. It appears that engineering training in the U.S.S.R. is characterised by the many hours spent at school each week and the shortness of the vacations. There is, therefore, much greater concentration of study compared with British universities, many of whose State-aided students waste their time working as labourers, waiters, and in other unskilled occupations when the universities are closed for months each year, instead of diligently pursuing the studies for which they have been granted scholarships. Tradition dies hard. It does not yet seem to be realised that these long vacations are not advantageous to students whose main object is to become technically competent to earn a living as quickly as possible, however desirable they may have been in the past when the graduates were the sons of the rich and who attended a university solely for the purpose of receiving a liberal education.

The desire of students to become scientists and engineers arises partly from the fact that the adulation of scientists and engineers in Russia makes this an attractive way of life, as well as one that may be somewhat more remunerative than others. Also, after completing their university training, such students are generally exempted from military service so that they may start technological work. It is thought that the numbers graduating in technological subjects in the U.S.S.R. are, and probably will be for some time, even greater than in the United States. There is, however, a much greater degree of specialisation which it is thought may result in a lack of adaptability such that the individual, if displaced from his specialisation, may become considerably less useful as a citizen.

The failure to realise the difference between a scientist and a technologist, or between an engineer and a computer of stresses, is also evident in Great Britain and in other countries, with the resulting danger that we may be misled into believing that large numbers of embryo scientists and engineers are being produced when in fact they are not. Early specialisation without a true basis of education will produce technologists and technicians but not scientists or engineers. On this subject a writer in the " Daily Telegraph " recently described the problem confronting a grammar school. " Here," he says, " everything possible seems to be done to prevent over-specialisation in the sixth forms. The best brains in the fifth forms show little bias towards either science or the arts. They have the makings of complete men. After less than a year in the sixth form the arts students are already beginning to express themselves with flexibility and precision and to show imagination and judgment in their work. The ' scientists ' of the same group are still, to all intents and purposes, inarticulate." This is common experience, and will undoubtedly be worsened when, next year, ordinary passes in English and another language will no longer be required by some universities. The intensive training in technological subjects of uneducated men will not help the nation to regain the supremacy in science that it had in the last century and has now lost ; it will produce mostly men who are content to let others do the thinking because they are themselves incapable of doing so.

# The Ultimate-load Method of Design.

## Safety, and the Working-stress Fallacy.

By A. L. L. BAKER, D.Sc., M.I.C.E.
PROFESSOR OF CONCRETE TECHNOLOGY,
IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

ALTHOUGH designers in reinforced concrete have been accustomed to base calculations on permissible working stresses, many of the formulæ used have been established from tests to destruction, so that in reality an ultimate-load (that is the load causing failure) basis of design has already been adopted. With the introduction of prestressed concrete it has become essential to reconsider and clarify the whole basis of concrete design so that factors of safety may be logically related to structural conditions and be consistent throughout a structure. In this article the term factor of safety is assumed to have its original meaning, that is the ultimate load divided by the working load. The term load factor of safety is sometimes used to avoid confusion with stress factor of safety, which is the ultimate stress divided by the working stress.

In *Fig.* 1 load is plotted against maximum stress at the critical sections of various structural members all having a load factor of safety of 2. The forms of the curves are as follows.

(1) Long Column.—Due to buckling, the stress increases at a much greater rate than the load.

(2) Simply-supported Prestressed Beam.—The compressive stress in the concrete is negative at no load, increases uniformly until cracking of the concrete occurs on the tensile side, then increases suddenly, followed by a fairly uniform rate of increase up to failure.

(3) Steel Tie-rod.—The stress increases uniformly up to failure, which is assumed to occur at the yield point. This is the only truly elastic case.

(4) Main Tensile Steel in a Simply-supported Reinforced Beam.—The stress increases uniformly and slowly until the concrete cracks, then increases suddenly, followed by a fairly uniform rate of increase up to failure.

(5) Main Tensile Steel at a Plastic-hinge Section of a Continuous Beam.—The curve is similar to (4) except that, towards failure, the steel yields and the plastic hinge opens. The load continues to increase, but the stress remains almost constant.

(6) Main Tensile Steel in a Simply-supported Prestressed Beam.—The stress is about two-thirds of the ultimate value at no load, increasing slightly until the concrete cracks; a sudden increase is then followed by a fairly uniform rate of increase until the beam fails.

These examples, which are typical, show that the working stress, that is the stress at half the load causing failure, gives no indication of the value of the load factor of safety, except in the case of the tie-rod (3) and approximately in the case of the tensile steel in a simply-supported reinforced concrete beam (4). In most reinforced and prestressed concrete structures, load and stress at critical sections do not have a simple linear relationship. It is therefore essential to calculate the ultimate load in order to determine the true factor of safety. A further important point in favour of relating calculations to the ultimate load is that they are much

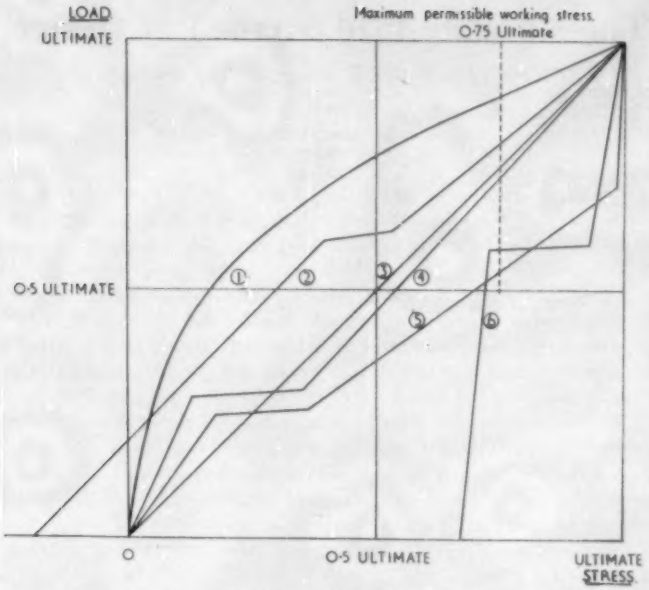


**Fig. 1.—Load and Maximum Stress at Critical Sections.**

(1) Concrete in a long column of high slenderness ratio. (2) Concrete in a simply-supported prestressed beam. (3) Steel in a tie-rod assuming that the yield-point stress is the ultimate stress. (4) Main tensile reinforcement in a simply-supported reinforced concrete beam. (5) Main tensile reinforcement at a plastic hinge in a continuous reinforced concrete beam. (6) Main tensile reinforcement in a simply-supported prestressed concrete beam.

simpler than elastic calculations for highly-redundant structures such as building frames. Also, by taking advantage of the redistribution of bending moments, important economies can be made.

The examples in *Fig.* 1 also indicate that to calculate the ultimate load only is not enough. The load-stress relationship of concrete and steel at every critical section needs to be considered at all stages of loading, particularly to ensure that there is no risk of high strains or stresses occurring at working load which might result in too rapid a deterioration of the structure due to fatigue or corrosion, or in undesirably large deformations. Curves 5 and 6 are particularly significant. In Curve 5 the stress in the steel at working load is greater than half the ultimate stress, and in such a case it would be necessary to ensure that at working load the deflection was not excessive, or that the widths of cracks in the concrete were not wide enough to cause rapid corrosion of the reinforcement. In curve 6 the stress in the steel at working load is about two-thirds of the ultimate stress. The concrete is highly compressed, and the risk of corrosion of the steel is therefore small. The prestress is opposed to the stress due to the load, and deflections are therefore small. However, at about 0·8 of the ultimate strength of the steel, some weakening of the steel or of the end-anchorages may occur due to fatigue.

Research is required to determine more precisely at what stress conditions in

regard to fatigue become critical. It may be important to have a margin of safety between the stress at working load and the critical stress at which the effects of fatigue become serious, since prestressing is a site operation and therefore subject to error. Particular care is required whenever small accidental increases of working stress approach the critical value of fatigue, especially when heavy live loads are frequently repeated. The danger of creep increasing the eccentricity of slender compressive members, or of accidental eccentricity greatly increasing the bending moment, needs considering in some cases. In fact whenever small changes in the strength of the material, the working stress, the conditions at the supports, or eccentricity produce great changes of the ultimate load, special care must be taken in assessing the ultimate load and stresses at working load.

Many other examples could be mentioned, but the foregoing are sufficient to show that, more often than not: (1) The ultimate strength of a structure must be calculated in order to determine the factor of safety. (2) The stress at working load and at slight over-load or over-prestress must be calculated approximately in order to ensure that an adequate margin of safety is provided against cracking that may permit corrosion of the steel or weakening due to fatigue, and so that deflections are not excessive. Limiting the working stress to 0·75 of the ultimate stress (*Fig.* 1) is satisfactory in many cases.

## Calculation of the Ultimate Load.

The ultimate strength at critical sections of structural members must be determined from the stresses produced in them, and from distributions of stress obtained from tests to destruction of full-size members. It is convenient to use the following notation:

$c_u$, strength of concrete cubes.
$c'$, compressive stress in concrete at the edge of a section.
$\alpha c'$, average compressive stress in the concrete.
$d$, effective depth of section.
$n_1 d$, depth of compressive zone to neutral axis.
$\gamma n_1 d$, depth to centre of compression.
$\varepsilon'_c$, ultimate compressive strain of the concrete.

Whenever factors such as $c_u$, $\alpha$, $\gamma$, and $\varepsilon'_c$ (references 1, 2, 3), which govern the ultimate strength, vary, it is necessary to know the deviation of a large number of test results. It is convenient to plot these as a frequency diagram or histogram and to assume the nearest Gaussian distribution. For example, the cube strength of a particular grade of concrete made according to a particular standard of quality-control may have a "standard deviation" ($\sigma$) of about 15 per cent. about the mean of a large number of tests. For such a case, about one cube in a hundred would have a strength less than $m - 2{\cdot}3\sigma$, where $m$ is the mean, and it would be reasonable to base calculations of the ultimate strength of structures made of such concrete on a minimum cube strength of $m - 2{\cdot}3\sigma$. In the actual structure the chances of weaker concrete occurring throughout a critical section would be very small; such concrete should be rejected by a reliable inspector, and a small quantity overlooked would be mixed with stronger concrete.

Similarly, all other factors included in the calculations should have safe minimum values based on the histogram of a large number of test results. In the terms $\alpha$ and $\gamma$, since there is a tendency for both to increase as $c_u$ becomes

lower, the safe limits adopted need not be as extreme as in the case of $c_u$. Thus, $\alpha c'$ varies approximately from $0{\cdot}45c_u$ to $0{\cdot}65c_u$ and $\gamma$ from 0·33 to 0·48. Reasonably safe limits that agree well with bending tests on beams are $\alpha c' = 0{\cdot}5c_u$ for high-grade concrete, $\alpha c' = 0{\cdot}6c_u$ for low-grade concrete, and $\gamma = 0{\cdot}4$ for all grades of concrete. Other factors having safe limits to be included in the calculations are (1) The eccentricity of the compressive forces causing buckling; (2) Thickening of sections to compensate for loss of strength towards the end of the required life of the structure as a result of fatigue, corrosion, or wear; and (3) Stresses due to changes of temperature and shrinking.

In redundant structures the ultimate distribution of bending moments must be determined by a theory such as that of plastic hinges (1, 2, 3), which gives results within about 10 per cent. of accuracy when the values assumed in the calculations are correct. Allowance, too, must be made when necessary for movement of the supports, a safe limiting value of the greatest movement being assumed, and if possible based on a full investigation of the sub-soil, particularly in compressibility. Such movements will not generally affect the ultimate distribution of bending moments, but will increase the rotations of plastic hinges.

It is important that all measurable influences that might affect ultimate strength be included in the calculations in a quantitative manner based on tests. This is much sounder than using less extreme values in the calculations and ignoring possible variations of movements of supports or eccentricities, and arbitrarily increasing the factor of safety. Such anomalies as different factors of safety for the reinforcement and the concrete in a beam are then avoided. A structure or structural member can have only one factor of safety. The distribution of the load assumed in the calculations must be the worst that might occur in relation to ultimate conditions of support, and increases must be made for possible dynamic effects or vibration. The maximum assumed working load must be based, as far as possible, on statistical information relating to similar structures or to the anticipated control of the load through physical or other conditions. A structure having a load factor of safety $F$ in accordance with these principles, if loaded with $F$ times the working load at the end of its required life, would be expected to fail simultaneously by overturning and by yielding or rupture at all critical sections if the safe minimum strength of the steel or concrete occurred at those sections and if the assumed safe maximum movement at the supports developed.

## Probability of Failure.

The theory of probability has a limited application in calculating the strength of reinforced concrete structures. Typical variations or histograms of the strength of test specimens and occasionally of loads may be used to determine the safe values to be used in the calculations. Similarly, from tests of a large number of structural members, safe values of $\alpha$, $\gamma$, and $e'_c$ defining stress distribution may be determined. These values may be adjusted to allow for trends which indicate that lower strength is generally accompanied by a better distribution of stress. When the safe minimum strength of the concrete is assumed to be $m - 2{\cdot}3\sigma$, it may be expected that about 99 per cent. of the cubes tested will have at least that strength. The chance of weaker concrete occurring throughout critical sections is

remote even if the strength of the concrete in the structure varies as much as the test specimens, except in columns where every section may be critical. It is probable, however, that the apparent weakness of occasional specimens would be due to faulty testing. There is, moreover, a risk of concrete in the structure being weakened by loss of grout due to rain or defective shuttering, inadequate compaction, or to inclusion of foreign matter. It is impossible to obtain statistics of such occurrences, but experience shows that, with reliable control of quality, failures do not occur under slight overload, and concrete in a structure appears to attain at least the strength indicated by $m - 2{\cdot}3\sigma$.

It is, however, impossible to calculate the probability of failure or use it as a criterion in design. Weakening of concrete in the structure due to lapses in the control of quality is random, both in regard to frequency and magnitude. The same can be said in regard to unforeseen conditions at the supports. To provide fully for such eventualities it would be necessary for concrete structures to be two or three times stronger than is required, using a high factor of safety such as 4 or 5. Such a policy would be foolish and even dangerous if the contractor took advantage of the high factor of safety and careless work were not rigorously prevented. A sound policy is to emphasise in the specification the fact that such defects will cause serious failures and are the responsibility of the contractor, who must avoid them by exercising the standard of control required. Inspection and testing must be absolutely foolproof so that the required standard is assured. High safety factors may encourage wide variations of quality, and hence inaccurate definition of safe limits of strength, which may result in lack of precise inspection.

The probability of failure cannot be computed since adequate statistics are not available, but may be indicated as follows. In the case of a single structure subjected to no relative settlement of its supports and having, say, ten stories supported by a frame of 500 beams and 60 columns, there would be about 1100 critical sections of the beams, and the columns would be critical throughout.

Assume the following conditions: (1) All concrete of strength less than the safe minimum were rejected, only one batch in a hundred and ten had the assumed safe minimum strength, and every tenth batch in the beams occurred in a critical section; there were fifty-five batches in each column. (2) Calculations were based on appropriate safe minimum strength and maximum working load and allowance made for plastic effects. (3) The critical sections of the beams were reinforced so that failure would start by crushing of the concrete.

If the factor of safety were 1 throughout, and there were no random causes of failure such as those mentioned previously, and the maximum working load were applied, then about 24 columns and one beam would probably fail at a critical section. (There is generally a chance that maximum working load will be applied once during the life of a structure.) Therefore all such structures would fail. If the factor of safety were 1 for the beams and 1·1 for the columns, the structure would fail at one critical beam-section. If the factor of safety were 1·1 for the beams and columns, none would fail. If a thousand such structures were designed for sites on a particular type of soil, where the assumed conditions occurred on only one site in ten, and safe values of the relative settlement of supports were assumed in the calculations, and if the factor of safety were 1 on the beams and 1·1 on the columns, then one structure in ten would fail at one critical beam section if no random causes of failure occurred.

If random causes of failure occurred which reduced to one-half the minimum strength of critical sections, or if twice the maximum working load were applied, and the factor of safety were 2 on the beams and 2·1 on the columns, then there would be the same number of failures as before, or no failures if the factor of safety were 2·1 throughout. It may therefore be assumed that a factor of safety of 2 allows for random occurrences of an extreme kind, which should always be obvious and so prevented or remedied. This concept of safety provides a more practical assessment of the margin of safety than a numerical value of the probability of failure based on statistics and including random effects that must be guessed.

In most reinforced concrete structures the beams and slabs are under-reinforced, so that failure starts by yielding of the steel. The risk of failure by crushing of the concrete is thereby further reduced provided that a slightly higher factor of safety is used for the columns. If the reinforcement is correctly placed, anchored, and bonded, there should be no risk of failure in tension if a factor of safety of 2 is used.

## Value of the Factor of Safety.

When safe limits are used for all the terms in the calculations, a factor of safety of 1·1 might be satisfactory for a fence post but, for structures in which the consequence of failure is serious, a factor of safety must be used which will ensure that the probability of failure is nil by the certain exclusion of all detectable dangerous random effects. Judgment alone can determine what the factor should be. Many thousands of simply-supported beams and slabs having no reserve of strength through redundancy or other causes, and which have periodically been subjected to full working load, have developed no sign of approaching failure. There is no reserve in strength due to variation in the quality of the steel. Such beams or slabs have been designed with a load factor of safety of 2 with regard to the main reinforcement, which under test would have started failure by yielding. Here, then, is a criterion for an upper limit of 2. The factor of safety obviously cannot be less than 1, and this could be used only for a structure the failure of which would not be serious. The possible variations of the strength of the materials, the maximum ultimate eccentricities of compressive members, the settlement of the supports, the redistribution of stresses and bending moments due to plasticity, loss of strength due to fatigue or corrosion or wear, the worst distribution of the maximum load, and dynamic effects or vibration are all included in the calculations, and based as far as possible on reliable tests. When several safe limits are multiplied in the calculations, the factor of safety may be adjusted to allow for the small probability of their occurring simultaneously, but this cannot be great since the range of possible factors is between 1 and 2 and, as will be seen, other influences are more important.

Two sets of factors influence the choice of the factor of safety, namely, (1) those included in the calculations and which are related to the probability of failure, and (2) the consequences of failure in regard to loss of life and injury to people, cost of replacement, and loss of use. In determining the factor of safety such influences may be given a " weight " so that the factor of safety is rationally adjusted when the " weight " is varied between possible extremes. The variation is small, and no advantage is gained by allocating separate " weights " to all the

TABLE I.

| Main influence | Details | Maximum "weight" ($W$) |
|---|---|---|
| Results of failure . . | Danger to persons. Cost of replacement. Loss of use | 8 |
| Workmanship and conditions of support | Standard of site control. Quality of materials | 4 |
| Load conditions . . | Nature of control of load. Possible variations of load | 4 |
| Importance of member in the structure | Proportion of total load carried. Possibility of transfer of load due to weakening. Proportion of member critical in regard to strength | 1 |
| Warning of failure . . | Degree of overload causing obvious large deformations, cracks, or other sign of failure | 1 |
| Reduction of strength . | Standard of maintenance. Conditions in regard to corrosion, fatigue, wear, or similar cause of weakening | 1 |
| Calculations . . . . | Accuracy of calculations. Number of safe limiting values included, or types of loading | 1 |
| | Total | 20 |

TABLE II.

| | | $W$ | | $W$ |
|---|---|---|---|---|
| Results of failure . . | Very serious in all aspects | 8 | Not serious | 0 |
| Workmanship and supports | Occasionally poor | 4 | Very good | 0 |
| Load conditions . . . | No control | 4 | Complete control | 0 |
| Importance of the member in the structure | Structure completely dependent on member | 1 | Not completely dependent | 0 |
| Warning of failure . . | None | 1 | Good warning | 0 |
| Reduction of strength . | Poor maintenance | 1 | Good maintenance | 0 |
| Calculations . . . . | Within about 10 per cent. of accuracy, with 1 set of loads and 1 safe limiting stress | 1 | Accurate. More than 1 set of loads and safe limiting stresses | 0 |

TABLE III.

| | Case (1) | Case (2) | Case (3) |
|---|---|---|---|
| Results of failure . . . . . | 8 | 3 | 3 |
| Workmanship . . . . . | 4 | 4 | 1 |
| Load conditions . . . . . | 4 | 4 | 2 |
| Importance of member . . . | 1 | 1 | 1 |
| Warning of failure . . . . . | 1 | 1 | — |
| Reduction of strength . . . | 1 | 1 | — |
| Calculations . . . . . | 1 | 1 | 1 |
| $\Sigma W$ | 20 | 15 | 8 |
| $F = \frac{\Sigma W}{20} + 1 =$ | 2 | 1·75 | 1·4 |

influences. It is simpler to group them together under main headings, as in *Table* I.

In a particular case the " weights " of the various influences are assessed according to the conditions. The factor of safety is then $\frac{\Sigma W}{20} + 1$, so that if the " weights " are all maxima the factor of safety is 2. Conditions for the extreme " weights " are as in *Table* II.

It must be remembered that the standard of workmanship, conditions of support, and reduction of strength are already allowed for in the calculations. The purpose of the factor of safety is to provide sufficient additional margin to ensure that the probability of failure is nil, unless some quite obvious abnormal condition or random effect beyond the control of the designer or inspector occurs. There is no purpose in attempting to avoid, by calculations, failure due to such causes. If extraneous matter is concreted into a column, if the reinforcement is not correctly placed, if an inspector fails to reject concrete made with excessively weak cement, failure may still occur even if the factor of safety is high. It would be unreasonable to build structures two or three times stronger than necessary to avoid such possibilities. They must be prevented by reliable control of construction and by testing. Over-loading a structure sufficiently to cause failure is inexcusable, and a designer need feel no responsibility so long as he has clearly defined the safe load. The factor of safety of about 1·75 to 2 proposed for structures in which results of failure would be serious allows for an overload of 25 per cent. to 50 per cent., and tests would indicate the security of the structure against normal loading.

**Example.**

The following example demonstrates how the factor of safety may be varied for the same structure as conditions change. A large-span reinforced concrete shed is designed to resist snow and wind loads. The main structural members are polygonal arches restrained at their ends by the ground. In the calculations allowance is therefore made for the maximum possible eccentricity of the arch ribs and lateral movement of the supports. The worst combination of dead load

and wind and snow loads, safe limits for all factors of strength, and allowance for corrosion of the reinforcement are assumed. Table III gives variations of the factor of safety for the following cases: (1) The shed is to be used as a factory, the workmanship is poor, the site exposed, it is to be constructed of reinforced concrete and the atmosphere will be corrosive. (2) As (1) but the shed is to be used for storing non-damageable materials. (3) As (2) but with good workmanship on a sheltered site (wind velocities known), using prestressed concrete, and the atmosphere will be non-corrosive.

It is assumed in cases (2) and (3) that the result of failure might be costly, in case (3) that the workmanship would be good but not faultless, that on the sheltered site wind and snow loads would be predictable, that cracking would give warning of failure, and that freedom from cracks would protect the reinforcement against corrosion. Calculations in all three cases are assumed to be not sufficiently precise to justify a reduction of the maximum " weight " due to the wind and snow loads occurring simultaneously. In case (3), if the conditions at the supports were poor, the " weight " of the conditions of load would need to be kept at 4.

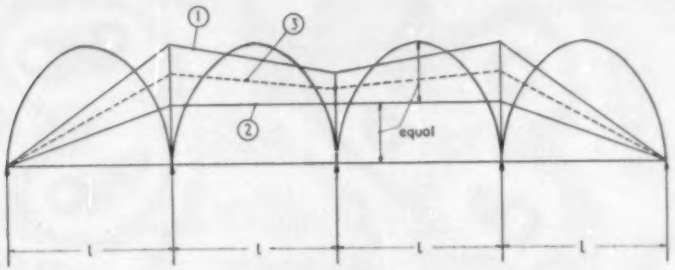


**Fig. 2.**

Where several influences, such as weakening due to fatigue, corrosion, or wear, are included under one heading, if any of them is liable to be serious in effect the full " weight " should be assumed.

### The Design of Continuous Beams and Redundant Frames.

The design of redundant frames by the plastic-hinge method provides a choice, varying between those in which elastic behaviour is assumed up to theoretical failure, and those in which development of plastic hinges having maximum rotations prior to failure is assumed, resulting in the most economical distribution of bending moments. The former method results in structures least subject to excessive deflection or cracking under the working load. The latter method provides better warning of overloading although there may be a risk of cracking due to the working load. The designer must, when necessary, balance the advantages of economy and warning of failure against the risk of excessive cracking or deformation due to the working load. Frequently a structure having the most economical distribution of bending moments, obtained by making full use of the assumption of plastic hinges, will be satisfactory at the working load. Occasionally it may be necessary to compromise and arrange the

reinforcement so that, at the ultimate load, a distribution of bending moments develops between that for a fully-elastic condition and that for the most economical distribution of bending moments.

*Fig.* 2 illustrates three possible distributions of bending moments for a continuous beam. (1) Economical, that is the bending moments at the supports equal the bending moments at midspan and plastic hinges develop their maximum rotation ; (2) Elastic conditions prevail throughout ; (3) There is a distribution of bending moments intermediate between (1) and (2). Finally, a further argument might be added against designing entirely from assumed elastic conditions. Stresses due to shrinkage, creep, and relative settlement, for example, are entirely ignored so that actual stresses usually do not correspond with theoretical working stresses. In tests to destruction, however, measured ultimate strengths correspond closely with the calculated strengths.

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(1) " Recent Research in Reinforced Concrete and its Application to Design." By the writer. Structural Paper No. 26, Inst. C.E., 1950. (2) " Further Research in Reinforced Concrete and its Application to Ultimate Load Design." By the writer. Paper No. 5894, Inst. C.E., 1953. (3) " Recent Research at Imperial College on the Design of Reinforced Concrete Frameworks by Ultimate Load Theory." By the writer. Reinforced Concrete Review, Vol. III, No. 6, 1954. (4) Report on Structural Safety. The Structural Engineer, Vol. XXXIV, No. 5, 1955.

## New Building at London Airport.

(*See facing page.*)

A NEW headquarters building for British Overseas Airways Corporation has recently been completed at London Airport (*Fig.* 1). The building includes offices and canteens, and it is intended that major aircraft maintenance work will be carried out in the new hangars.

The building is of reinforced concrete with some brick facings and includes four hangars with a total floor area of 188,000 sq. ft. Each hangar is 336 ft. wide by 140 ft. long and can accommodate three four-engined aircraft on each side of the main workshop (*Fig.* 2). The complete building is 867 ft. long by 420 ft. wide and 66 ft. high, and has a total floor area of about 1,000,000 sq. ft. Each hangar has a door opening 300 ft. wide by 45 ft. high spanned by two reinforced concrete cantilevers supported on pylons and balanced by counterweights of 1000 tons (*Fig.* 3). Between the two cantilevers is suspended the main beam which supports a gantry crane (the load from which is assumed to be 5 tons at 9 ft. centres) and reinforced concrete lattice beams designed to support a load of 150 lb. per square foot. The building was designed on a horizontal module of 18 ft. and a vertical module of 11 ft., and is estimated to have cost about £3,000,000.

The consulting engineers were Sir Owen Williams & Partners and the contractors Messrs. W. & C. French, Ltd.

Fig. 1.—New Buildings at London Airport.

Fig. 2.—One of the Workshops.

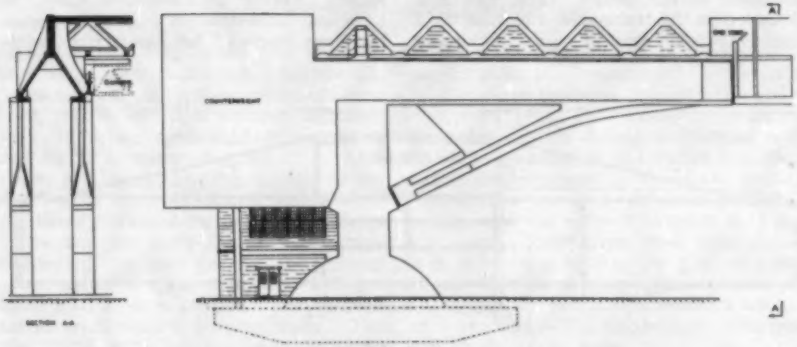

Fig. 3.—Part Elevation of Hangar Door Opening.

(*See page* 302.)

# A New Type of Hangar Roof.

An aircraft hangar with a thin corrugated roof is being built near Kansas City, U.S.A. These roofs are on opposite sides of a central office building, which also serves as an anchorage for the cables that support them (*Fig.* 1). Each roof covers an area of 818 ft. by 150 ft. and the corrugations are at right angles to the longitudinal axis of the hangar. The central block is 100 ft. wide and 3 stories high. The cables supporting the roofs are anchored in concrete walls 30 ft. high that span 100 ft. between the columns. There are 28 such walls spaced at 30-ft. intervals (*Fig.* 2). Four cables extend from the end of each wall to support the roof. Each cable consists of four strands of 2½ in. diameter with a tensile strength of 752,000 lb. They are anchored in the roof through steel sleeves, 10 in. diameter and 7 ft. 9 in. long, which are buried in the concrete.

The roof varies in thickness from 3½ in. to 7 in., and is designed as a folded plate (or prismatic) structure. The corrugations have a pitch of 30 ft. and a rise of 5 ft. 9 in., and the inclined cables are anchored in the valleys. The horizontal component of the thrust of the cable produces a negative bending moment in the roof, which tends to counterbalance the positive moments due to the imposed loads.

A snow load of 30 lb. per square foot, and an upward pressure up to a maximum of 60 lb. per square foot at the leading edge of the roof due to the wind, were assumed in the design. The roof was designed in the transverse direction for a horizontal wind load of 30 lb. per square foot acting on the entire length of the building. For longitudinal strength, the roof was designed for a load of 30 lb. per square foot on the end wall and end anchor-wall, plus a load of 15 lb. per square foot on all the other anchor-walls. The anchor-walls also carry the second and third floors of the central building, which are suspended on four 2½-in. diameter bars at each wall.

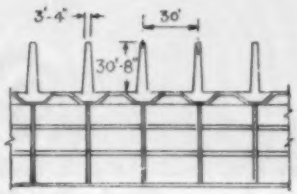


Fig. 2.

It is possible for tensile stresses to occur in either the top or bottom of the walls, depending upon loading conditions. In the bottom tension is resisted by reinforcement and in the top by reinforcement and two prestressing cables that extend the length of each wall. This was necessary because of the small cross section of the wall.

The engineers are Messrs. Burns & McDonnell, in collaboration with Messrs. Ammann & Whitney. The contractors are the MacDonald Construction Co., and Messrs. Footer & Creighton Co. The foregoing is abstracted from "Engineering News-Record" for January 26, 1956.

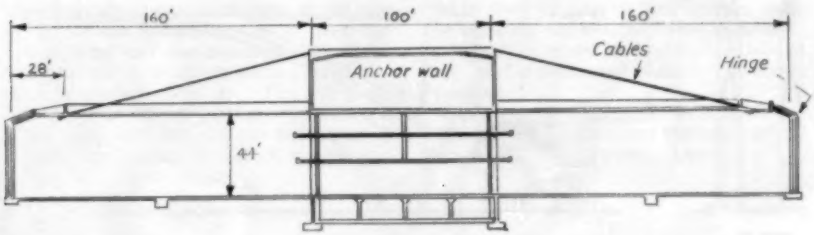


Fig. 1.

# Extension of a Furniture Store.

Two stories have been added on the roof of Messrs. Waring & Gillow's furniture store in Western Avenue, near London. The frame was erected in fifteen weeks. The original building (*Fig.* 1) is a reinforced concrete framed structure 220 ft. long, 97 ft. wide, and 45 ft. high, and has a basement and three stories each about 14 ft. high. There are no internal partitions. It was built about 35 years ago, and was designed with a view to the present extension. A lift-shaft 82 ft. high is provided in the centre of the building, the existing lift-shaft at one end of the building has been extended, and a loading annex with sliding doors and a cantilevered canopy has been constructed. Some innovations include reinforced concrete precast columns without haunches for beam seatings and made in lengths to suit one or two story heights.

The arrangement of the columns of the new fourth story is identical with that in the three stories of the original building. There are six rows of columns longitudinally, the two central rows being 16 ft. apart to form a corridor and the other rows at 20 ft. centres. The columns are at 20 ft. centres longitudinally. The top (fifth) story has two uninterrupted areas 40 ft. wide, between a corridor 16 ft. wide, along the length of the building. The two central rows of columns and those around the perimeter are of two-story height. The remaining columns are of single-story height and are used in the fourth story only. In the top floor the primary beams extend across the width of the building and secondary beams extend lengthwise. This arrangement is reversed in the roof (*Fig.* 2).

The columns of two-story (26-ft. 6-in.) height support the beams of the top floor and the roof, and were made with a gap of 2 ft. 6 in. in the concrete at fifth-floor level (*Fig.* 3). The concrete on each side of the gap is connected by a mild steel lattice welded together, and independent of the main reinforcement. In the case of the outer columns, the gap is partly concreted (*Fig.* 4). These connections resist the stresses during erection as well as those assumed in the design and also act as reinforcement for the in-situ joints. The interior two-story columns are 12 in. square and the outer columns 1 ft. 3 in. by 9 in. They have steel base-plates 2 ft. 6 in. by 1 ft. 6 in. by $\frac{3}{4}$ in. or 1 in. thick. The connecting lattice consists of four $\frac{7}{8}$-in. bars to which is welded a lattice of $\frac{3}{8}$-in. bars. The single-story columns are 11 ft. $4\frac{1}{2}$ in. long.

The lower part of the stem of each primary beam is made of precast concrete

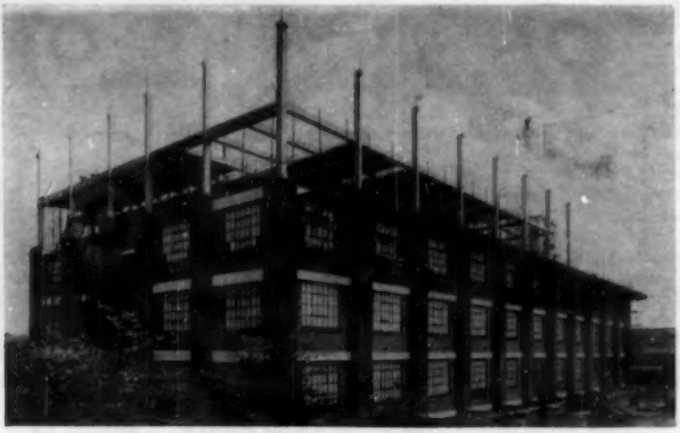

**Fig. 1.—Extension during Construction.**

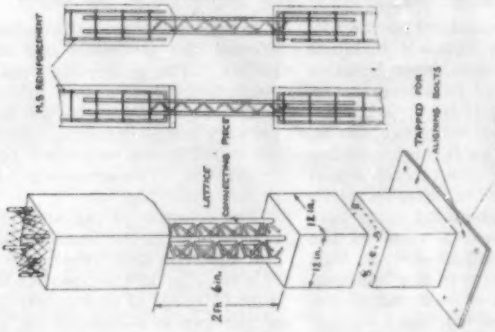


Fig. 3.—Details of Two-Story Columns at Intermediate Floor Level.

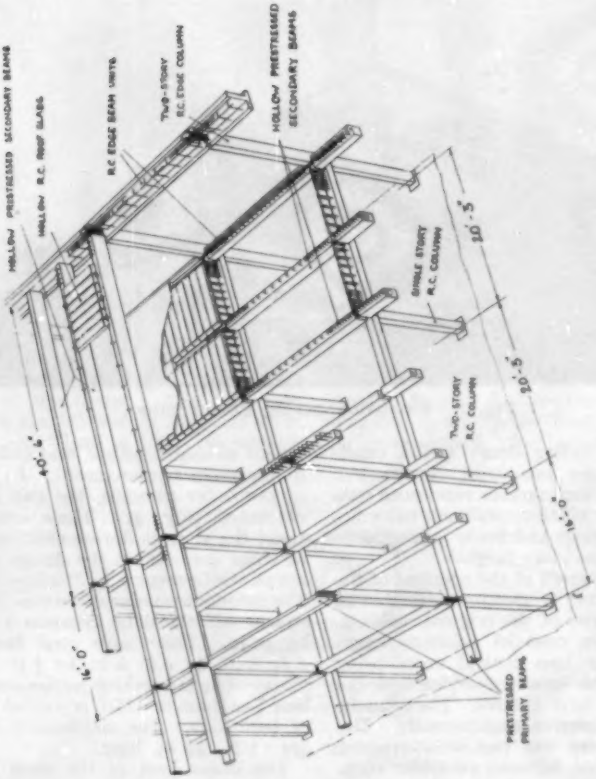


Fig. 2.—General Arrangement.

and either prestressed or reinforced. The upper part of the stem and the flange at the top are formed of reinforced concrete cast in situ. Each secondary beam consists of a precast stem, prestressed or reinforced, and a flange formed by the ends of adjacent floor slabs and a reinforced in-situ filling (*Figs.* 5, 6, and 7). All the prestressing was by the pre-tensioning process, and the beams were propped during erection.

**Fig. 4.—Junction of Beams and Columns at Top Floor.**

**Fig. 5.—Placing Precast Slabs for New Top Floor.**

In the top story the lower part of the stems of the primary beams are prestressed. These are 12 in. wide by 9 in. deep. There are cut-outs at the ends of the longest beams to clear the lattice in the cut-away sections of the outer columns, and at one end there is a stool 12 in. deep to provide a bearing for the two adjacent outer beams. All the beams have stirrups projecting 1 ft. 8 in. as reinforcement for the top part of the stem (*Fig.* 7). The in-situ flanges are 3 ft. wide.

The secondary beams carrying the floor of the top story are hollow; they are 12 in. wide by 1 ft. 3 in. deep, with stirrups projecting above the top surface. The hollow cores are about 6 in. square. The flanges are 2 ft. 8 in. wide and are formed by the tapered ends of floor slabs 6 in. thick and an in-situ filling. The floor slabs span between the secondary tee-beams with a bearing of 2 in. at each end.

The reinforced outer beams (*Fig.* 8) are ell-shaped and are made continuous by top reinforcement in the in-situ concrete. The beams along the ends of the building are primary beams of lengths to suit the column spacings. The secondary beams along the sides generally resemble the primary edge-beams. The columns, primary outer beams, secondary beams, and floor slabs are connected by interlocking bearings, reinforcement, and in-situ concrete.

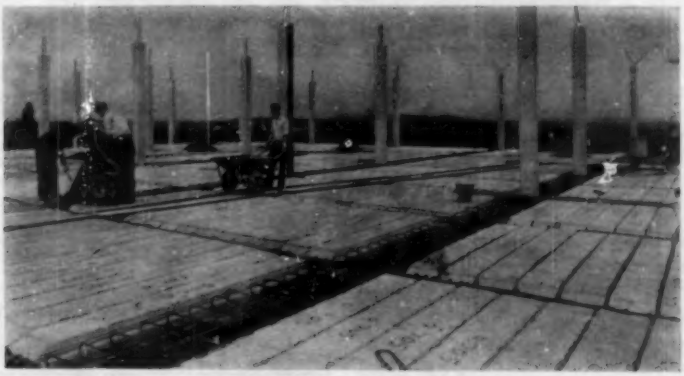

**Fig. 6.—Concreting the Beams of the New Top Floor.**

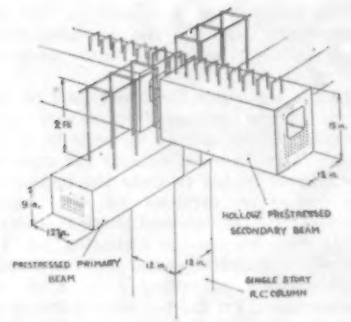


**Fig. 7.—Junction of Single-story Columns and Floor Beams.**

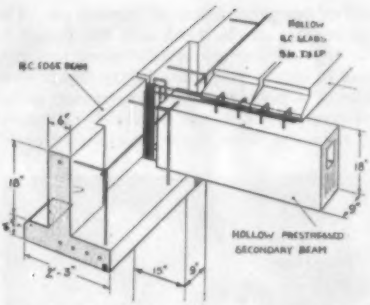


**Fig. 8.—Junction of an Outer Column and Beam at Roof Level.**

At roof level the primary beams extend the length of the building. Secondary beams span the central corridor of 16 ft. and the two side bays of 40 ft. The primary beams are composite tee-beams similar to those used for the top floor but their depth is greater to accommodate the secondary beams which are 1 ft. 6 in. deep. The secondary beams are composite tee-beams with prestressed precast stems.

The roof comprises hollow reinforced precast slabs 5 in. thick and roof-lights in openings 5 ft. square. A reinforced concrete floor for a tank room is suspended from the primary and secondary roof beams.

The loading dock is 180 ft. long and tapers from 53 ft. 3 in. to 10 ft. 3 in. wide, and has a cantilevered canopy projecting 16 ft. All the columns, and some of the beams in which camber would be undesirable, are of reinforced precast concrete. The remaining beams are of prestressed precast concrete. The main beams carrying the roof are composite tee-beams, with precast stems and flanges cast in situ, supported by the columns of the loading dock and by steel brackets fixed to the columns of the old building. The roof is of hollow slabs similar to those used for the main roof. The canopy comprises prestressed precast planks 9 ft. long supported by prestressed precast cantilevered beams at 2 ft. 3 in. centres. The cantilevered beams are connected at the front by a beam cast in place and supported at the fulcrum by reinforced concrete beams spanning between the external columns. These beams, 5 ft. 9 in. behind the fulcrum, are supported by the roof beams.

The architects are Messrs. Thomas Mitchell & Partners and the consulting engineer Mr. W. A. Mitchell. The general contractors were Messrs. Haymills, Ltd., and the frame was made and supplied by Concrete, Ltd.

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# Prestressed Silos for Sugar.

Two silos, with a total capacity of 16,000 tons of refined sugar, have been built at Poppleton, York, for the British Sugar Corporation, Ltd. The silos (*Fig.* 1) are 66 ft. diameter and 100 ft. high and are built on reinforced concrete columns 9 ft. 6 in. high to provide a basement for conveying machinery. A steel conveyor gantry 13 ft. wide by 18 ft. high crosses the top of the two silos and there is an elevator tower 13 ft. square and 145 ft. high.

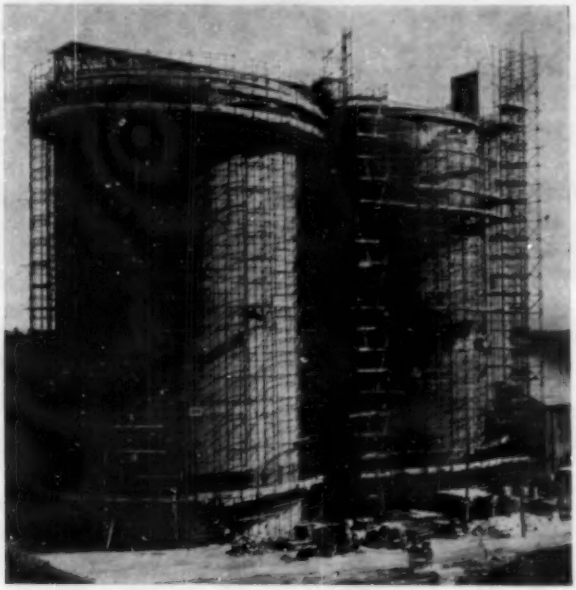

**Fig. 1.—Prestressed Silos under Construction.**

The foundations comprise 483 cast-in-situ piles with an average length of 25 ft. capped by a reinforced concrete slab 1 ft. 9 in. thick which carries columns 1 ft. 6 in. square at 8 ft. centres and circular walls 12 in. thick (*Fig.* 2). These walls were constructed in a single lift with a sliding shutter 20 ft. long mounted on rails. The walls of the silos are of prestressed concrete 8 in. thick and, owing to the large diameter, at the base a full head of sugar has to be resisted. Reinforcement was provided to resist wind and other forces during construction, vertical bending moments during stressing, and temperature changes after construction.

The walls were built with sliding shutters lifted by a new type of hydraulic jack (*Fig.* 3) supplied by Tangyes, Ltd. The shutters were 4 ft. high and were later reduced to 3 ft. 8 in. to simplify the placing of the concrete. Forty jacks were spaced evenly around the wall to raise the load of 80 tons. A vertical steel " climbing " bar of 1 in. diameter passed through the centre of each jack, and the casing of the jack was fixed to the shutters. There were two sets of gripping gears built into the jack, one set allowing an upward movement of the jack-casing only and the other set allowing an upward movement of the annular piston within the jack. Oil from a central pump at a pressure of 1000 lb. per square inch caused the casing to ascend the climbing bar whilst the

piston remained stationary. When the pressure was released a spring caused the piston also to ascend the climbing bar. Each stroke of the piston elevated the jack and shutters ¼ in. Provision was made for each jack to be adjusted separately if necessary.

The difficulty of maintaining a true circle of such large diameter was overcome by attaching the frame of the steel roof to the shutters (*Fig.* 4). This also simplified the fixing of the steel roof. The conveyor bridge incorporated in the roof, however, imposed uneven loading and the measures taken to meet this on the first silo were not entirely satisfactory. On the second silo jacks were used successfully in pairs to carry the heavier loads.

The concrete for the walls was specified to have a minimum cube strength of 5000 lb. per square inch at 28 days, and the rich mixture of 1 : 1·19 : 2·41 with a water-cement ratio of 0·43, which had to be used, tended to cause some difficulty

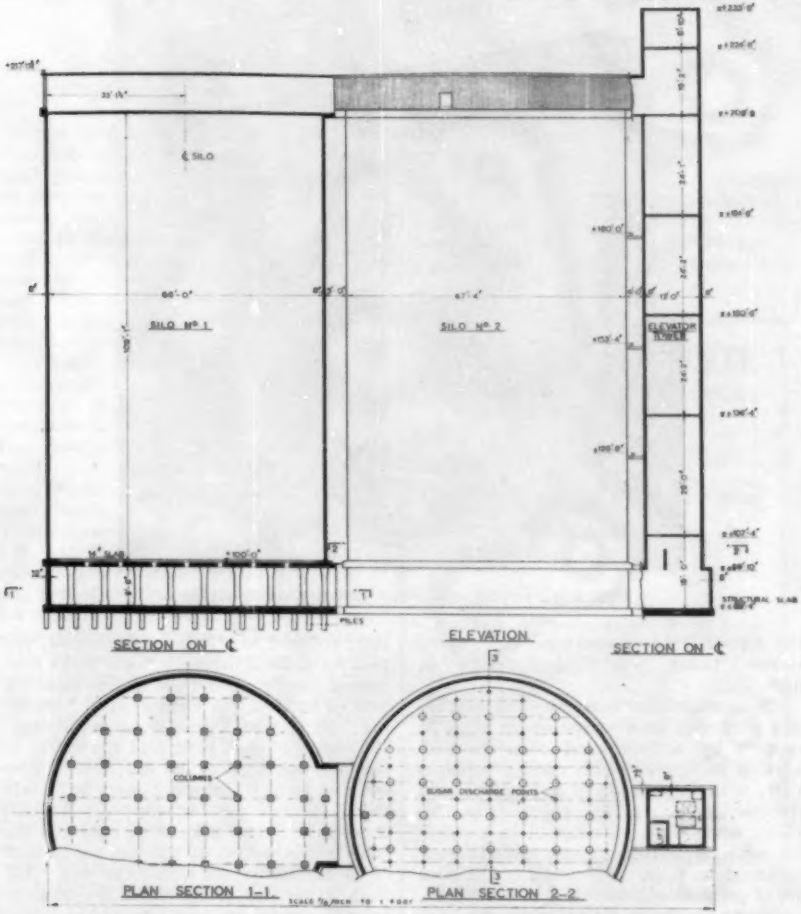


**Fig. 2.—Elevation and Sections of Silos.**

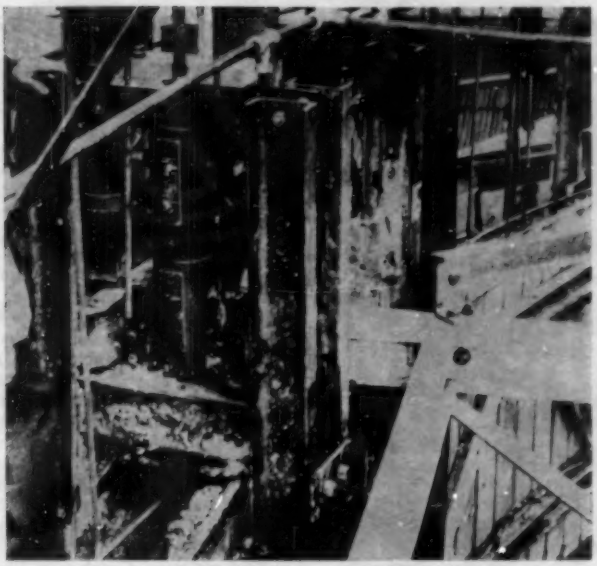

Fig. 3.—Hydraulic Jack for Lifting Shutters.

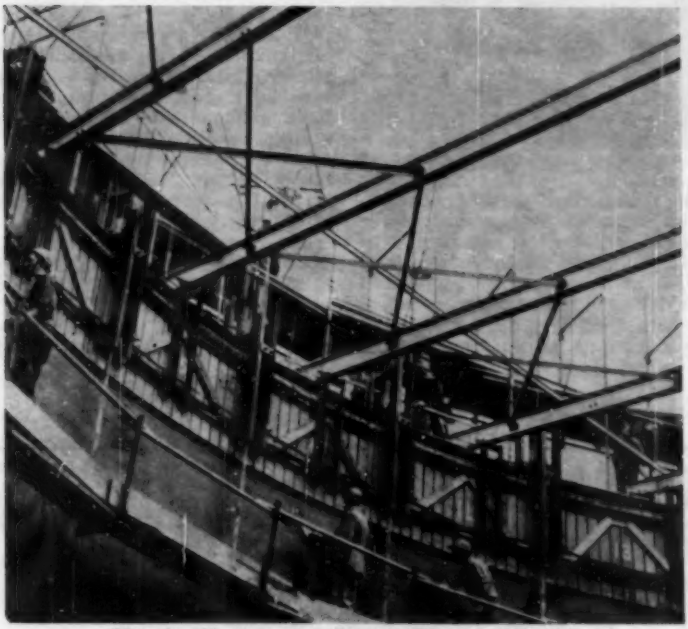

Fig. 4.—Shutters Attached to Frame of Steel Roof.

**Fig. 5.—Cable Anchorages.**

with the sliding shutters. This was overcome by controlling the consistency of the concrete and the rate of climb. The concrete was conveyed by barrow from a hopper at the top of the hoist and deposited in the shutters by means of short chutes. Some difficulties were experienced during the construction of the first silo which were avoided on the second, which rose at an average rate of 9¾ in. per hour. No special surface treatment was used to protect the concrete against any possible chemical action of the sugar.

Prestressing was by the Gifford-Udall system, with 0·276-in. wires outside the walls protected by gunite. Each wire embraced half the circumference. The wires were tensioned in pairs on opposite sides and the anchorages were alternated between two diameters at right angles to distribute the stresses evenly. The spacing of the circumferential wires varied from ⅞ in. at the bottom of the wall to 1 ft. at the top. The tension in the steel was 61 tons per square inch at the anchorage reducing (due to friction) to 34 tons per square inch 90 deg. from the anchorage. Vertical mild steel bars of small diameter kept the wires from the concrete to reduce friction during tensioning. The load was transferred from one anchor to the other by means of short pieces of steel channel (*Fig.* 5).

The elevator tower was built of reinforced concrete. The walls are 8 in. thick and tied to the adjacent silo. Intermediate floors are of precast concrete to allow for modification of machinery. The reinforced concrete was a 1 : 2 : 3·7 mixture with a water-cement ratio of 0·46 and had a minimum cube strength of 4500 lb. per square inch at 28 days. For reinforced and prestressed concrete aggregate of ¾ in. to ⅛ in. grading was used, and all materials were measured by weight. A 14/10 electrically-driven horizontal-drum mixer was used. The civil engineering work was completed in September, 1955, in 28 weeks. The design was carried out in conjunction with the British Sugar Corporation, Ltd., and the construction was by Messrs. John Laing & Son, Ltd.

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# The Fineness Modulus and the Grading of Aggregates.

We have received the following from Mr. F. S. Fulton, Director of the Concrete Association of South Africa.

The fineness modulus of an aggregate is a factor obtained by adding the total percentages of material retained on each of the standard sieves and dividing the sum by 100, as shown in *Table* I. This

TABLE I.—EXAMPLE OF FINENESS MODULUS OF SAND.

| B.S. sieve | Retained on sieve (oz.) | Percentage of total weight | Total percentage retained | Total percentage passing |
|---|---|---|---|---|
| $\frac{3}{8}$ in. | 0 | 0 | 0 | 100 |
| No. 7 | 1·84 | 9·2 | 9·2 | 90·8 |
| No. 14 | 5·50 | 27·5 | 36·7 | 63·3 |
| No. 25 | 3·86 | 19·3 | 56·0 | 44·0 |
| No. 52 | 5·40 | 27·0 | 83·0 | 17·0 |
| No. 100 | 2·30 | 11·5 | 94·5 | 5·5 |
| Passing No. 100 | 1·10 | 5·5 | | |
| | 20·00 | 100·0 | 279·4 | |

Fineness modulus, 279/100 = 2·79.

provides an index of the coarseness or fineness of the material, but it does not describe the grading. The grading curve of the sand in *Table* I and the method of calculating the fineness modulus show that this index is the area (the stepped diagram XPY in *Fig.* 1a) bounded by the grading curve and line XY (coinciding roughly with the No. 150 sieve) divided by 100; that is, *XY* times the average width of the diagram divided by 100 or, since *XY* is 100, the index equals the average width of the diagram. (The error in calculating the fineness modulus due to neglecting the material that passes the No. 100 sieve is negligible. When the method of calculating the fineness modulus has been established the actual position of the base XY is also unimportant.)

*Fig.* 1b shows that curves ab, aghb, ef, and cd confine equal areas, and accordingly represent sands of equal fineness modulus, although the gradings are very different. It is obvious that an infinite number of gradings, either continuous or discontinuous, can have the same fineness modulus. The method of calculating the index and curves of cumulative percentages passing standard sieves may have obscured its actual meaning, which is simply the average size of the particles passing each sieve rather than the size of the meshes of the sieves. A return to curves of actual, and not cumulative, size fractions, together with the application of statistical methods, indicate that a useful qualifying index may be obtained.

The example in *Table* I will be considered. *Fig.* 2 shows the percentages retained on each sieve plotted against the sieve sizes. If the size fractions are numbered minus 100 = 0, 100 to 52 = 1, 52 to 25 = 2, etc., by shifting the coordinates the figure becomes a diagram of actual percentages of each size-fraction

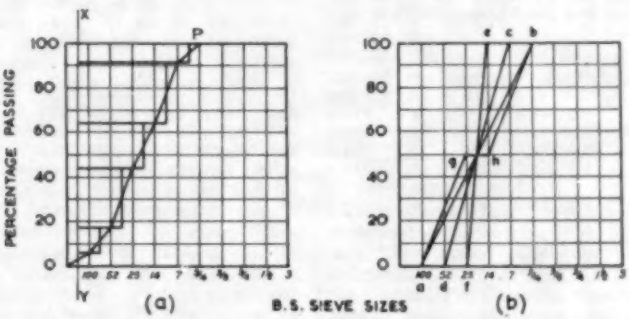


**Fig. 1.—Interpretation of Fineness Modulus.**

retained. (The actual position of the base-line O, representing minus 100 material, is arbitrary. In computing an index no great error results.) Since the effect of the minus-100 material may be neglected, the average particle size or fineness modulus may now be computed directly.

$$\tfrac{1}{100}(9{\cdot}2 \times 5 + 27{\cdot}5 \times 4 + 19{\cdot}3 \times 3 + 27 \times 2 + 11{\cdot}5 \times 1) = 2{\cdot}79$$

as before. The distribution of the particle sizes, in so far as they deviate from the average size or fineness modulus, is indicated by the standard deviation. In general statistical analysis, the value of the standard deviation is given by

$$\sqrt{\frac{(x_1-\bar{x})^2+(x_2-\bar{x})^2 \ldots, +(x_n-\bar{x})^2+}{n-1}},$$

in which $x_1$, $x_2$, and $x_n$ are individual values and $\bar{x}$ is the arithmetical mean of $n$ values.

Where $p_1$, $p_2$, $p_3$, etc., are the percentages which occur within certain groups or size fractions, we may write

$$\text{S.D.} = \sqrt{\frac{p_1(x_1-\bar{x})^2 + p_2(x_2-\bar{x})^2 \ldots,}{100}},$$

in which $x_1$, $x_2$, etc., are now the mean values of each group.

Applying this formula to the example, the standard deviation for sand A is

$$\sqrt{\frac{183}{100}} = 1{\cdot}35$$

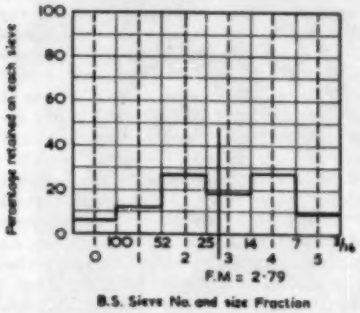


**Fig. 2.—Grading Diagram of Percentages Retained on B.S. Sieves.**

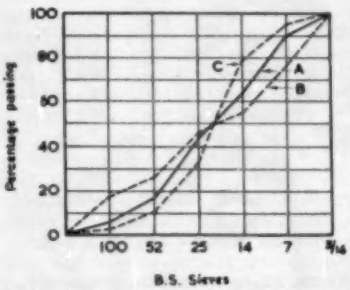


**Fig. 3.—Comparison of three Sands with the same Fineness Modulus.**

TABLE II.

| B.S. sieve | Percentage weight retained on sieve | | | Fineness modulus factor | 100 × F.M. | | | Square of difference $(x-\bar{x})^2$ | Sum of squares | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sand A | Sand B | Sand C | | A | B | C | | A | B | C |
| 3/16 in. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| No. 7 | 9·2 | 23·1 | 5·1 | 5 | 46·0 | 115·5 | 25·5 | $(5-2{\cdot}79)^2$ | 45·0 | 113·0 | 25·0 |
| No. 14 | 27·5 | 22·4 | 15·3 | 4 | 110·0 | 89·6 | 61·2 | $(4-2{\cdot}79)^2$ | 40·3 | 32·8 | 22·4 |
| No. 25 | 19·3 | 9·0 | 46·8 | 3 | 57·9 | 27·0 | 140·4 | $(3-2{\cdot}79)^2$ | 0·8 | 0·4 | 2·1 |
| No. 52 | 27·0 | 19·8 | 22·4 | 2 | 54·0 | 39·6 | 44·8 | $(2-2{\cdot}79)^2$ | 16·8 | 12·4 | 13·9 |
| No. 100 | 11·5 | 7·7 | 7·5 | 1 | 11·5 | 7·7 | 7·5 | $(1-2{\cdot}79)^2$ | 37·0 | 24·7 | 24·0 |
| Passing No. 100 | 5·5 | 18·0 | 2·9 | 0 | 0 | 0 | 0 | $(0-2{\cdot}79)^2$ | 42·8 | 140·0 | 22·6 |
| Total | 100 | 100 | 100 | | 279 | 279 | 279 | | 183 | 323 | 110 |
| Fineness modulus | | | | | 2·79 | 2·79 | 2·79 | Standard deviation | 1·35 | 1·80 | 1·05 |

and similarly for sands B and C as shown in *Table* II. The minus-100 material must be included in the calculation of the standard deviation, as its neglect would lead to a significant change in the value of the index. The lower the standard deviation the higher the percentage of particles close to the average size. Conversely, a high standard deviation indicates a larger proportion of particles in the coarse and fine fractions.

A consideration of sands A, B, and C, all having a fineness modulus of 2·79 but with different gradings (*Fig.* 3), makes this clearer. The three curves are within the limits specified in B.S. No. 882, except that sand B contains more material passing the 100 sieve. The analysis of the grading is given in *Table* II.

The application of this method to a large number of gradings obtained in practice will no doubt reveal desirable limits of the standard deviation. Remembering, however, that the grading for sand A lies fairly centrally between the extremes of the B.S. gradings, it would appear that a standard deviation of 1·3 to 1·4 is desirable, while standard deviations of 1·8 and 1 would represent inferior size distributions.

## Book Reviews.

**"Design of Prestressed Concrete Structures."** By T. Y. Lin. (London. 1955. Chapman & Hall, Ltd. Price 92s.)

DEVELOPMENT of prestressed concrete in the U.S.A. was, until about the year 1950, largely confined to methods that could be considerably mechanised, as, for example, in the prestressing of circular tanks by the "merry-go-round" system and in the production of pressure pipes and precast beams. It seems that it was not until after the completion of Walnut Lane bridge, in Philadelphia, that American engineers were convinced that prestressing could economically be applied to the construction of bridges and buildings. In the last five years, however, the use of prestressed concrete has increased greatly, particularly in the construction of short-span bridges. Most of the European systems are used in the U.S.A., and the author describes also two or three which have, so far as we know, not been used in this country. One utilises stranded-wire cables, available in sizes allowing working strengths of 3,000 lb. to 200,000 lb., anchored in a manner similar to that used for the cables of suspension bridges. Another system uses ¼-in. wires anchored against plates by "rivet-heads" formed at the ends of the wires. American contractors appear to have been successful in using lightweight concrete for prestressed precast products, which may enable beams of longer spans to be precast than at present when their lengths are often restricted by the difficulty of handling heavy members.

Methods of design of simply-supported beams and slabs, and of continuous beams, are very clearly presented and the notation is readily understandable. Frames are briefly mentioned. Partial prestressing and the use of untensioned reinforcement are considered, as are ultimate-load design based on the methods due to Mr. Charles S. Whitney, and the selection of suitable load-factors. Resistance to fire and corrosion, fatigue, and the effects of dynamic loads are dealt with in the last chapter, and some useful appendixes give data relating to several systems of prestressing together with the criteria for design of prestressed concrete highway bridges published by the U.S. Bureau of Public Roads. The least satisfactory parts are those dealing with the calculation of stresses near anchors and the effects of shrinkage and creep of in-situ concrete used in conjunction with precast members, but on the whole this well-written and well-illustrated book is one of the best yet published on the subject.—J. E. G.

**"Prestressed Concrete Statically-Indeterminate Structures."** [Issued by the Cement and Concrete Association and obtainable from Concrete Publications, Ltd., London. Price 25s. 5.50 dollars in Canada and the U.S.A.]

IN this volume are given in full the papers presented at the International Symposium on "Prestressed Concrete Statically-indeterminate Structures" organised by the Cement and Concrete Association and held in London in September 1951. The papers, which are well illustrated by

drawings and photographs, are as follows: "Continuity of Prestressed Concrete Structures: the Practical Aspect", by A. J. Harris; "The Analysis of Statically-indeterminate Structures subjected to Prestress", by D. W. Cracknell and W. A. Knight; "Experimental Work on Interconnected Prestressed Beams", by P. B. Morice; "Continuity in Prestressed Concrete", by Professor G. Magnel; "Determination of Continuity Bending Moments in Prestressed Continuous Beams", by E. G. Trimble; "Continuity using Post-tensioned High-tensile Bars", by G. O. Kee and S. Jampel; "Theoretical Treatment of Continuity in Prestressed Concrete", by Y. Guyon. The discussions on the papers are printed in full, and form a valuable feature of the book.

**"Kempe's Engineers Handbook."** [London: Morgan Brothers (Publishers), Ltd. 2 vols. Price 75s.]

Now in its 61st year, this valuable work of 3000 pages has been still further revised and improved. All branches of civil, electrical and mechanical engineering are dealt with in such a thorough manner that the volumes are an almost indispensable work of reference. There is an excellent chapter on concrete and reinforced concrete.

**"The Supervision of Civil Engineering Construction."** By A. C. Twort. (London: Edward Arnold (Publishers), Ltd. Price 25s.

THIS work of 228 pages is primarily intended for resident engineers on civil engineering contracts of medium size, and will also be useful to contractors. It is in three parts dealing with site organisation, work on the site, and the preparation of contract documents, and the chapter headings are as follows: Types of contract and organisation; Duties of the resident engineer; The first few days on works; Programme and progress charts; Office records; Setting-out, excavations and foundations; Concrete site work; Reinforcement, brickwork, dampcourses, renderings, partitions, stone work and roofing; Flooring, tiling, windows, and doors; Sub-contract and prime-cost items; Pipe laying; Claims; Specifications; Bills of quantities; Drawings. The author has evidently had much experience of his subject, and it is a pity that so much space is occupied by what is often called "journalese" writing instead of useful information and more illustrations.

**"Thermal Insulation of Buildings."** By G. D. Nash, J. Comrie, and H. F. Broughton. (London. 1955. H.M.S.O. Price 12s. 6d.)

THE greater part of this book comprises tabulated data giving the thermal insulating values and costs of insulating materials for a wide variety of methods of construction of walls, roofs and floors. There is also information on the properties, commercially available sizes, and methods of application of thirty-seven insulating materials. The general principles upon which the tables are based are given in the first chapter, which contains sufficient information to enable the tabulated data to be applied.

**"Undersökning av kontinuerliga betong-balkar vid långtgående betongstukning"** (Investigation of Continuous Concrete Beams at Far-advanced Compressive Strains in Concrete). By Henrik Nylander and Sven Sahlin.

**"Dimensionering av korsarmerade betongplattor"** (Design of Two-way Concrete Slabs). By Henrik Nylander.

**"Effekt av långtgående betongstukning vid betongbalk påverkad av böjande moment"** (Effect of Far-advanced Compressive Strains of Concrete in Reinforced Concrete Beams Submitted to Bending Moments). By Sven Sahlin.

THESE three papers, issued by the Institutionen för Byggnadsstatik (Kungl. Teknisk Högskolan) are printed in the Swedish language, and have short summaries in English. No prices are stated.

## Books Received.

**"Estudo e Controle do Betão no Estaleirho."** By A. de Sousa Coutinho.

**"Os Aterros da Estrada Luanda-Catete Algumas Sugestões Sobre a Compactação de Aterros de Estrada."** By Ulpio Nascimento.

**"Notas Sobre os Trabalhos Relativos à Compactação Apresentados ao III Congresso Internacional de Mecânica de Solos, 1953."** By Ulpio Nascimento, Abel Simões, and Fernando Branco.

**"Compactação em Barragens de Terra."** By Manuel Rocha, José Folque, and Guy de Castro. [Lisbon: Laboratório Nacional de Engenharia Civil. Prices not stated.]

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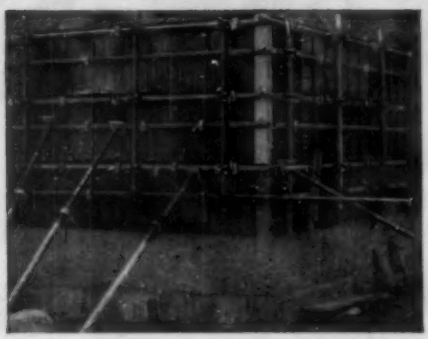

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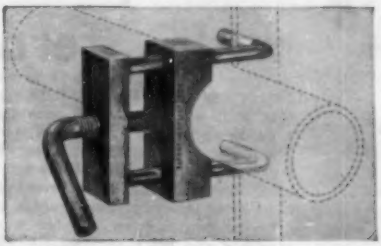

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# Reconstruction of a Quay Wall.

## PRESTRESSED TIES.

In a paper published in the Annales des Ponts et Chaussées M. Desbazeille described the reconstruction of the wall of the Carenage Quay at Dieppe. This quay was almost completely destroyed during the war and the explosion of mines had displaced and tilted the foundation of the wall.

The old wall, about 550 ft. long, was constructed during the years 1906 to 1907 of plain concrete with brick facings and supported on two rows of reinforced concrete piles. At intervals of about 33 ft. there are counterforts of reinforced concrete to which are attached tie-beams connecting the wall to an anchor-beam of T-shape with the flange vertically and which bears against a wall of steel sheet-piles. The lower tie-beam is of prestressed concrete about 4 ft. deep by 2 ft. 6 in. wide, and contains 18 cables each comprising 18 wires of 0·2 in.

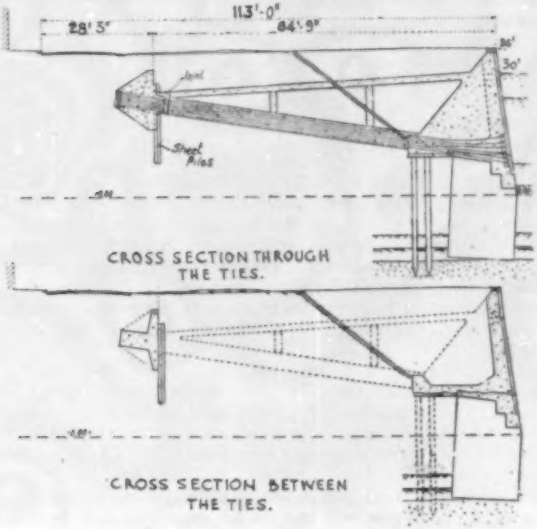


**Fig. 1. Details of the New Wall.**

was founded on caissons bedded on gravel about 16 ft. below the level of low water at ordinary spring tides. The new wall of reinforced concrete has been constructed on the old foundation but, because of the displacement of this, the new wall was tied to an anchor-beam about 85 ft. from the face of the quay.

The new wall (*Fig.* 1) has the same alignment as the old wall and comprises a stem, about 4 ft. thick, of reinforced concrete with a brick facing, a base 24 ft. 6 in. wide by about 2 ft. 3 in. thick, and a beam 5 ft. 3 in. deep at the rear, diameter. The upper tie-beam is of reinforced concrete and is about 1 ft. 8 in. square.

Because of the inclination of the old foundation (about 3 deg. to 6 deg. from the vertical) it was essential to ensure that no further forward movement would take place. This was achieved by tying the quay wall to the anchor-beam so that the tensioning of the cables consolidated the earth in front of the sheet piles. In concreting the two ties a gap about 1 ft. wide was left at the junction of the ties with the anchor-beam. The cables were

placed in steel tubes cast in the wall, the lower tie, and the anchor-beam, with sliding sleeves in the joint. Before concreting the joint 14 cables were tensioned, each by a force of about 30 tons. Concrete was then cast in the joint, and after it had hardened the remaining four cables were tensioned. The prestressing was carried out by the Freyssinet system and the cables were anchored by cones in precast slabs placed in the shutters for the anchor-beam and the wall. After tensioning the cables were grouted but, despite the precautions taken, difficulty was experienced due to the escape of grout from one tube to another. To make easier the threading of the cables, which were over 100 ft. long, through the tubes the contractor welded together the wires at the leading ends of the cables and no trouble was encountered in this operation.

The stem of the wall was constructed using the outer brick wall as shuttering on one face. The bricks were laid in alternate courses of headers and stretchers to key the facing to the concrete. Expansion joints were not provided although it is now considered that these would have been advisable as some cracks have occurred where recesses were formed in the wall to accommodate ladders.

The design of the wall was by the Service des Ponts et Chaussées and the contractors were the Société d'Entreprise Marbeau.

## The late A. E. Wynn.

It is with much regret that we record the death of Albert Edward Wynn, who passed away last month in South Africa after a short illness. After graduating at Birmingham University and being employed on civil engineering works in this country, Wynn went to the U.S.A. in the early 1920's and built up a flourishing business designing and building reinforced concrete structures. He returned to this country in the 1930's, and after further work on large reinforced concrete structures, including the Earl's Court Exhibition building in London, he undertook the task of starting the Cement and Concrete Association of South Africa, of which he was Director until his retirement a few years ago.

Wynn will be best known to most of our readers by his two books, "Design and Construction of Formwork for Concrete Structures" and "Estimating and Cost Keeping for Concrete Structures". The first editions of these books were written while he was in the U.S.A., and are based on his own experience. His wide knowledge of the subjects, and his perspicacity in not being misled by all of the newer and much-advertised ideas, are shown by the fact that, although they have needed very little revision, these are still the standard works on the subjects.

The passing of A. E. Wynn will sadden his many friends, to whom the benefit of his great experience was unfailingly given.

### Conference on Roads.

An international conference on roads, organised by the British Road Federation, is to be held in London from September 17 to 20, 1956. Delegates are expected from many countries, and papers will be presented dealing particularly with the provision of motor-roads. Details may be had from the Federation at 4A Bloomsbury Square, London, W.C.1.

### Plywood Shuttering.

A brochure describing the uses of plywood shuttering, and with graphs showing the deflections of plywood panels with various spans and subjected to various pressures of concrete, has been issued by British Plywood Manufacturers, Ltd., of Wharf Road, Ponders End, Middlesex, from whom copies can be obtained free of charge.

Vibro cast-in-place reinforced concrete piles are used in all parts of the world.

The illustration shows Albany House, Durban. This is a 14-storey block of offices, and 201 Vibro piles, average length 28 ft., with a working load of 40 tons each, were used in the foundation work to carry this building.

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# Machine for Making Soil-cement Road Bases.

**Fig. 1.—Machine for Consolidating Road Foundations.**

In our March 1955 number we referred to a new machine for making soil-cement bases for roads. This machine is shown in the accompanying illustrations. In *Fig.* 1 are seen, from left to right, the tractor that pulls the machine, the hopper for the cement, the rotor, and the tamper. The cement hopper (*Fig.* 2) evenly distributes the cement over the soil, and the rotor breaks up the soil to the required depth, adds any water that may be required, and mixes the soil and cement. The tamper consolidates the mixture as shown in *Fig.* 3. This machine has already been used for the construction of runways at an airfield. The capacity of the machine, which is made by Rotary Hoes, Ltd., of Horndon, Essex, on a strip 6 ft. wide by 6 in. thick is 6 ft. per minute.

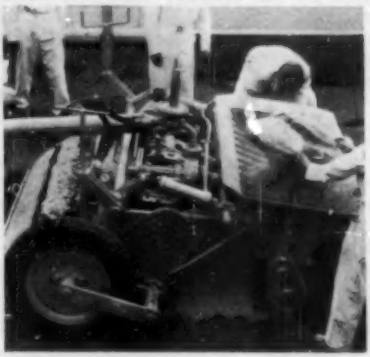

**Fig. 2.—The Cement Hopper and Spreader and the Rotor.**

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**Bursaries in Concrete Technology**

Applications are invited for Bursaries in Concrete Technology tenable from October, 1956.

The value of the Bursaries is £400 per annum, out of which the University fees have to be paid. They will be awarded for one year and may in certain circumstances be renewed for a second year.

Applicants must hold a Degree in Engineering, or its equivalent. The course will include post-graduate lectures, design, drawing, and laboratory work.

Applications, giving full details of qualifications and experience, must be received by the Registrar, The University, Leeds, 2, not later than 4th June, 1956.

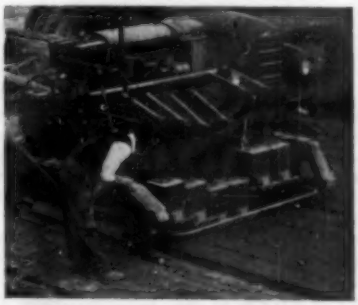

**Fig. 3.—The Tampers.**

# The Association for Bridge and Structural Engineering.

VOLUME 15 of the Proceedings of the Association for Bridge and Structural Engineering • contains sixteen papers printed in the English or French language. Summaries of the papers relating to concrete are as follows.

"MATRIX-ANALYSIS OF SUCCESSIVE MOMENT-DISTRIBUTION." By S. O. Asplund (Gothenburg). Printed in English.—The procedure of successive moment-distribution is interpreted by an infinite matrix series whose definite sum is also given. It is shown that this sum coincides with the corresponding finite expression obtained without approximations by the ordinary theory of elastic structures. It is demonstrated that the matrix series for moment-distribution in stages (as defined) is asymptotic to a geometrical series whose common ratio and various sums can be approximated. The matrix method given is exemplified by applying it to a building frame.

"THE APPLICATION OF PREFABRICATION TO ARCH BRIDGES." By C. Fernández Casado (Madrid). Printed in French.—In all the cases described the initial structural element is a three-hinged arch. The hinges are generally provisional and serve to control the position of the line of thrust under dead load. The half-arches defined by the hinges constitute the basic elements of prefabrication. They are cast on the site or at a factory, and erected with steel towers. In some cases the precast members constitute the final elements of construction. Generally, however, they are used as shuttering and form part of members cast in situ.

"HOOP REINFORCEMENT IN THE SIPHON OF LES GRANGES." By M. Mary (Paris). Printed in French.—The author describes the circumferential reinforcement used in the hydro-electric works of Bort for the installation of a prestressed concrete conduit with a diameter of 13 ft. and a working pressure of 185 lb. per square inch. Particular attention is given to the means adopted for overcoming the difficulties due to friction which causes an uneven distribution of stress along the rings, with uneconomical use of steel. After a review of the methods used to overcome this difficulty, the report describes how the rings of parallel wires were bedded on small metal plates, which were pushed forward intermittently during the tensioning of the steel, with a vibrating hammer, and by this means an improvement in the stress distribution along the rings was achieved.

"STRESSES IN NON-UNIFORMLY SUPPORTED CYLINDRICAL TANKS." By William A. Nash and Wasfi Hijab (University of Florida, U.S.A.) Printed in English.—An equilibrium analysis is presented for a vertical cylindrical tank subject to an axial loading distributed uniformly around the circumference at its upper extremity and supported non-uniformly by the foundation at its lower extremity. Infinite series expressions, compatible with boundary conditions, are assumed for the three orthogonal displacement components, and the principle of minimum potential energy is employed to determine the various coefficients of the series. From these displacements the normal and shearing stresses in the tank may be determined to any desired degree of accuracy by the usual stress-displacement relations for thin shells.

"THE DESIGN OF THE VIERENDEEL GIRDER." By E. Robert and L. Musette (Belgium). Printed in French.—Attention is directed to Professor Stüssi's two basic rules for the design of a Vierendeel girder. Recommended procedures are given.

"DESIGN AND CONSTRUCTION OF REINFORCED SHELL STRUCTURES OF NON-UNIFORM THICKNESS SUPPORTED ON ROLLERS." By Yoshikatsu Tsuboi and Kinji Akino (Tokyo).—Printed in English.—The paper describes the design and construction of a reinforced concrete thin spherical shell with a radius of 50 metres and a diameter of 50 metres—built in Japan. The approximate analytical methods for a shallow dome and for the case of non-uniform thickness are discussed, the solutions being based on Bessel functions for both cases. These solutions can be applied to practical design.

"PRELIMINARY STUDY OF COMPOSITE ACTION IN FRAMED BUILDINGS." By R. H. Wood (England). Printed in English.—The stiffening effect of walls

• Zurich: Verlag Leeman. Price 38 Swiss Francs.

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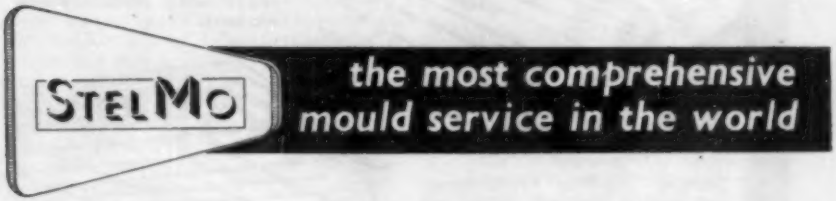


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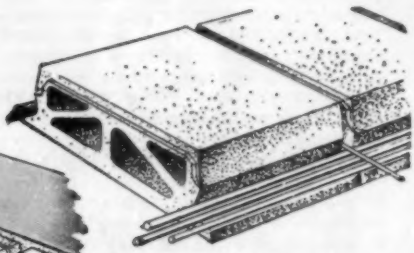

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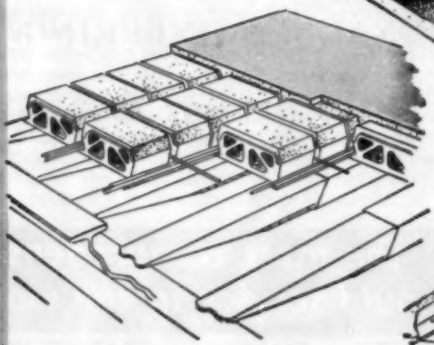
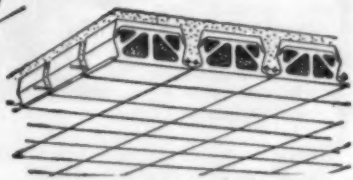


Showing Two-Way Reinforcement and Hollow Concrete Blocks laid on Trianco Telescopic Centers.



Illustrating the continuous Soffit with natural Key to which plaster readily adheres without hacking or other preparation to form finished ceiling.

## 2 WAY REINFORCED SUSPENDED CONCRETE FLOORS

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PARKFIELD CONCRETE PRODUCTS COMPANY LIMITED
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and floors in framed structures is reviewed. It is stated that the main problem appears to be the determination of the actual load distribution on the beams of a supporting frame, which can vary considerably. In this connection there is an analogy between the stiffening effects of walls and floors. The combined behaviour of floors supported on beams is examined at working (elastic) conditions and at impending (plastic) collapse. It is shown that the loads on the beams at collapse may be decided by the position of the reinforcement. In an effort to reduce the quantity of reinforcement by limit-analysis methods it is shown that with reinforced concrete floors an " elastic " design forms a good starting point for the most economical " collapse " design.

" DESIGN DIAGRAM FOR COMPOSITE BEAMS." By Masaru Yasumi and Hirokazu Okamura (Japan).—This paper gives diagrams for designing composite beams.

## Awards in Technology.

A NATIONAL COUNCIL for Awards in Technology is being constituted, on the advice of the National Advisory Council on Education for Industry and Commerce, to create and administer awards in technology which will be nationally recognised and will be available to students in technical colleges who successfully complete higher technological courses approved by the Council. These awards will represent an educational qualification comparable to a university first degree. Post-graduate awards may be established later.

The Council will be an independent body consisting of five members appointed by the Minister of Education and three appointed from their members by each of two Boards of Studies. Of the five members appointed by the Minister, four are chosen for their distinction in technology and one for knowledge of local education authority administration. Of the three appointed by each Board, at least one will be a member of the teaching staff of a technical college.

The Boards of Studies will be responsible to the Council for all matters concerned with the approval of courses, including the curricula and syllabuses proposed for the awards, the standard of the college work related to the courses for which approval is sought, the standard of admission to the courses and of the final examinations, the qualifications of the teachers, the accommodation and equipment, and the conditions for the conduct of the examinations. The Council will not be an external examining body, but will ensure that the conditions under which the colleges propose to teach and examine the students are satisfactory. Where these conditions are met, the colleges will be recognised for the courses concerned and for the awards they make to students.

Civil and structural engineering are represented on the Boards by Professor A. J. S. Pippard, M.B.E. (Imperial College of Science and Technology), and Mr. P. E. Sleight (Brighton Technical College) nominated by the Institution of Civil Engineers, and by Sir Donald Bailey, O.B.E., and Dr. S. B. Hamilton, O.B.E., nominated by the Institution of Structural Engineers.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Department of Civil Engineering

**Bursaries in Concrete Technology**

NOTICE IS HEREBY GIVEN that the election to Bursaries in Concrete Technology, tenable as from October, 1956, will take place in June, 1956.

Candidates must hold a degree in Engineering at the time of taking up the award, and must also have a good knowledge of the theory of structures.

Bursaries are of the value of £460, out of which the College Tuition Fee of £60 has to be paid; the amount may be increased to a maximum of £760, depending on the qualifications and length and nature of industrial experience. The Bursary is for the normal College session extending from October until the following June.

The course will be postgraduate, and Bursars who successfully complete the course will be eligible for the award of the Diploma of the Imperial College (D.I.C.).

Applications must be received on or before 1st June, 1956, by the DEPUTY REGISTRAR, CITY AND GUILDS COLLEGE, Exhibition Road, London, S.W.7, who will, on written request, send full information and application forms.

### British Standard for Prestressing Wire.

THE British Standards Institution is preparing standards for steels for prestressed concrete, and Part I, " Plain Hard Drawn Steel Wire for Prestressed Concrete ", has now been issued (price 2*s*. 6*d*.). The principal requirements are the following.

The steel must not contain more than 0·05 per cent. of sulphur or of phosphorus ; it must be free from defects such as splits and bad edges ; tolerances of 0·002 in. are permitted in the diameter of wires of 0·104 in. diameter and over and of 0·001 in. in wires thinner than 0·104 in. diameter ; a tolerance of 5 tons per square inch above the specified tensile strength is permitted ; non-proportional elongation in proof tests must be not more than 0·1 per cent. at a stress equal to 70 per cent. of the minimum tensile strength ordered.

The tensile strengths normally available are given as follows (in tons per square inch) : 0·276 in. diameter, 95 to 105 ; 0·2 in. diameter, 100 to 110 ; 0·16 in. diameter, 110 to 120 ; 0·128 in. diameter, 120 to 130 ; 0·104 in. diameter, 130 to 140 ; 0·08 in. diameter, 140 to 150.

### Lectures on Building.

THE following lectures have been arranged by the Ministry of Works. Admission is free.

Thermal Insulation, by J. A. Godfrey. Municipal College, Victoria Circus, Southend. March 14. 7.30 p.m.

Legal Obligations of Building Contractors, by John J. Clerke. Technical College, Forest Road, London, E.17. March 14. 7.15 p.m. Also at City College, Ipswich Road, Norwich. March 22. 7.30 p.m.

Safety, Health and Welfare in the Building Industry, by A. G. Thomas. C.W.S. Lecture Room, Seaview Road, Colwyn Bay. March 15. 7 p.m.

Introduction to Prestressed Concrete, by R. C. Blyth. Technical College, Hempstead Road, Watford. March 15. 7 p.m.

Problems of Plastering and Rendering, by L. A. Ragsdale. Technical College, Northgate, Darlington. March 20. 7 p.m.

Some Aspects of Building Contracts, by Norman P. Greig. County Hotel, Rainsford Road, Chelmsford. March 21. 7.30 p.m.

### A Garage with a Floor Warming System.

AN electrical warming system has been installed in 1440 sq. ft. of floors at the motor showrooms of Messrs. Burton & Deakin, Ltd., Orpington. The cables, 1272 ft. long and of 0·0015 sq. in. cross-sectional area, were laid on the concrete 4 in. apart, and comprise three single-phase circuits each of 7·2 kW. A thermostatic and time-switch control ensures that electricity is used only at off-peak hours. The cables are laid on the floor by means of the roller shown in *Fig.* 1, and at the returns they are placed in grooves formed by the template shown in *Fig.* 2. The cables are then covered by the concrete floor topping.

**Fig. 1.**

**Fig. 2.**

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**Advertisements must reach this office by the 23rd of the month preceding publication.**

**SITUATIONS VACANT.**

SITUATIONS VACANT. Senior reinforced concrete designers wanted by leading reinforced concrete engineers and contractors. Must be fully conversant with Code of Practice, L.C.C. Bye-Laws, and able to design light-framed structures from estimating stage to final details. Five-days' week. Pension scheme. Progressive position. Starting salary from £900 upwards according to ability. This year's holiday arrangements honoured. Juniors also required, similar conditions. Write BOX 4172, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Assistant structural engineers required with experience of reinforced concrete design. Experience of precast techniques advantageous. Salary according to experience and qualifications. Apply in writing to TECHNICAL MANAGER, THE SCOTTISH CONSTRUCTION CO., LTD., Sighthill Industrial Estate, Edinburgh.

LONDON COUNTY COUNCIL

ARCHITECT'S DEPARTMENT

STRUCTURAL ENGINEERS required in District Surveyors' Service. Salaries up to £945, according to qualifications and experience. Particulars and application form from ARCHITECT (AR/EK/DS/3), The County Hall, London, S.E.1. (1922.)

SITUATION VACANT. Consulting engineers, Westminster, require senior assistant with considerable experience in road and bridge design. High salary and good prospects for suitable applicant. Write in confidence, stating age, qualifications and full details of experience, to BOX 4233, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Civil engineering draughtsman, experienced in road and bridge work, required by consulting engineers, Westminster. High salary and good prospects. Write, stating age and details of experience. BOX 4234, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete detailers and detailer-draughtsmen required by consulting engineer, Westminster. Progressive salary scales and five-days' week. Applicants with a minimum of two years' experience should write, giving full particulars, to A. E. BEER, 96 St. George's Square, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete designers with good theoretical knowledge and experience in industrial design required by civil engineers and contractors in Westminster. Good prospects in expanding business. Pension scheme. Staff canteen. Apply in writing, stating age, qualifications, experience, salary required, to TILEMAN & CO., LTD., Romney House, Tufton Street, London, S.W.1.

*(Continued on next page.)*


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**MISCELLANEOUS ADVERTISEMENTS.**
*(Continued from page lxxi.)*

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SENIOR ENGINEER DESIGNERS fully qualified and experienced in Civil and Structural Reinforced Concrete Engineering. Structural steelwork experience desirable. Accustomed to full responsibility and supervision of staff. Preferable age limits 28–35. Salary range £1,000–£1,500.

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DRAUGHTSMEN with experience of neat and expeditious preparation of reinforced concrete arrangements and steel details. Salary to suit capabilities.

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42, Portland Place, London, W.1.

SITUATIONS VACANT. Air Ministry Works Designs Branch require in London structural engineering designer/draughtsmen for reinforced concrete or structural steelwork, with sound technical training and several years' varied experience in design/detailing of (*a*) Reinforced concrete construction for all types of buildings, or (*b*) Steel framed sheds, warehouses and similar buildings. Salaries up to £850 per annum. Starting pay based on age, qualifications and experience. Paid overtime. Long-term possibilities with promotion and pensionable prospects. Natural born British subjects. Write, stating age, qualifications, employment details, including type of work done, to any Employment Exchange, quoting Order No. Borough 2304.

SITUATIONS VACANT. Reinforced concrete detailers required for London office. Previous experience in similar capacity necessary. Attractive conditions of employment. Apply in writing, giving brief particulars of education, experience, age, and quoting L.128, to BRAITHWAITE & Co. ENGINEERS, LTD., 14–16 Regent Street, London, S.W.1.

SITUATION VACANT. Reinforced concrete design engineer required by specialist reinforcement designer/suppliers. A.M.I.Struct.E. essential, preferably with constructional experience. Permanent superannuated position with scope for advancement. Write or telephone ROM RIVER CO., LTD., St. Richard's House, Eversholt Street, London, N.W.1. Euston 7814.

SITUATION VACANT. Civil engineering draughtsman required for work in London office of large civil engineering contractors. Work of varied nature, with scope for initiative and advancement. Commencing salary £600–£800 depending on experience. Five-days' week and luncheon vouchers. Pension scheme operates. Box 4228, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Reinforced concrete detailer required for consulting engineer's office. Interesting work in all types of concrete framed buildings. Good experience and draughtsmanship essential. Apply in writing, giving details of experience, age, etc., to F. J. SAMUELY, 8 Hamilton Place, London, W.1.

SITUATIONS VACANT. Taylor Woodrow Construction, Limited, require senior and assistant technical staff in the following categories: Structural engineers with reinforced concrete experience, for Head Office. Design and planning engineers, for Head Office. Site engineers. Soil mechanics/geologist. Industrial chemist with cement experience. Interesting and progressive positions for the right men. Well-paid and pensionable posts. Write, giving full details, which will be treated confidentially, to M. D. ENGINEER, Ruislip Road, Southall, Middlesex.

SITUATIONS VACANT. Reinforced concrete draughtsmen with experience in detailing industrial structures required by civil engineers and contractors in Westminster. Good prospects in expanding business. Pension scheme. Staff canteen. Apply in writing, stating age, experience, salary required, to TILEMAN & Co., LTD., Romney House, Tufton Street, London, S.W.1.

## THE TRUSSED CONCRETE STEEL COMPANY LIMITED

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SITUATION VACANT. Consulting engineers, Westminster, require assistant experienced in the design and/or detailing of reinforced concrete bridges. High salary, interesting work and excellent prospects. Write, stating age, qualifications, and full details of experience. Box 4235, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Designer-draughtsmen and juniors required by concrete specialists for both prestressed and reinforced concrete work. Excellent prospects for the right man, attractive salary, pension scheme, and sports club facilities. Apply in writing, giving age, full particulars of training and experience, to the PERSONNEL MANAGER, PIERHEAD ENGINEERING DIVISION, THE UNIT CONSTRUCTION CO. LTD., 34 St. James's Street, London, S.W.1.

SITUATION VACANT. Consulting structural and civil engineers require senior assistant engineer with at least five years' office experience since graduateship and National Service, to supervise the design and detailing of reinforced concrete structural frameworks and foundations. Salary £750–£900 according to age, qualifications, and experience. Superannuation scheme and luncheon vouchers. Apply ANDREWS, KENT & STONE, 60–66 Wardour Street, London, W.1.

SITUATION VACANT. Structural designer-draughtsman required by the design department of Kodak, Ltd. Should be experienced in the design of structures in reinforced concrete and structural steelwork, and the preparation of working drawings. Minimum qualification—Higher National Certificate in structural engineering or equivalent. The position can be regarded as permanent and progressive. The company operates a non-contributory pension and insurance plan. Apply by letter to the PERSONNEL DEPARTMENT, KODAK, LTD. (Factories), Wealdstone, Middx.

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SITUATION VACANT. Graduate engineer with at least two years' design experience required for engineering department of London contractors. Full particulars to BOX 4242, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Junior draughtsman required for consulting engineers office in Croydon area, preferably with some experience in structural engineering, and keenness to learn. H.N.C. standard or equivalent. Write, giving particulars of education, experience, and salary required, to BERNARD L. CLARK, M.I.Struct.E., M.Soc.C.E. (France), M.Cons.E., 6 Onslow Gardens, Sanderstead, Surrey.

SITUATIONS VACANT. Ministry of Works requires assistant structural engineers in London and provinces. Candidates must have passed A.M.I.Struct.E. examination, or Parts I and II of A.M.I.C.E. final examination, or hold an exempting qualification, with experience in development and preparation of design and working drawings for steel frame and reinforced concrete structures. One post calls for experience in assessment of soil characteristics for design of structural foundations, roads and earthworks. Salary range: London £761–£1,182 per annum according to age and experience, provincial rates slightly less. Prospects of promotion and permanency. Application forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26 King Street, London, S.W.1, quoting Ref. E 388/5/A. Closing date 26 March 1956.

SITUATION VACANT. Reinforced concrete contractors specialising in floor construction invite applications for senior position in London head office. Applicants must possess engineering knowledge, and be between 35 and 45 years of age, with extensive experience in the building trade, and possess managerial capacity. The position affords an excellent opportunity for advancement and is pensionable. Write, giving fullest particulars. BOX 4243, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. A young man wanted as structural engineer-in-trainng to spend one year in research department, followed by experience on building sites, with view to permanent pensioned appointment as structural engineering adviser after qualifying as A.M.I.Struct.E. or equivalent. Applicant should preferably have reached graduate standard with good grounding in reinforced and prestressed concrete. Apply in writing, giving age and full particulars of training and experience, to the PERSONNEL MANAGER, SECTION B.1., THE UNIT CONSTRUCTION CO., LTD., 34 St. James's Street, London, S.W.1.

SITUATIONS VACANT. Designer-detailers and detailers, experienced in reinforced concrete, required for London professional office. Knowledge of steelwork an advantage but not essential. The work is varied and offers scope for initiative and advancement. Opportunity for site visits, and possibility of joining resident engineer's staff later. Five-days' week, pension scheme. Apply, stating experience, and salary required, to FARMER AND DARK, Romney House, Tufton Street, London, S.W.1.

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SITUATIONS VACANT. TWISTEEL REINFORCEMENT, LTD., have vacancies for designers and detailers in their London drawing offices. Apply, stating experience, to 43 Upper Grosvenor Street, London, W.1.

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SITUATIONS VACANT. Design engineers, draughtsmen, and detailers, with experience in reinforced concrete or structural steelwork, required urgently for permanent positions in consulting engineer's offices. Steady expansion of firm provides opportunities for suitable candidates to undertake responsible posts covering all aspects of design work, or to broaden their experience and capabilities, on a generous salary scale. BOX 4249, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

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Candidates must be Corporate Members of the Institution of Civil Engineers or (by examination) the Institution of Structural Engineers and have had experience of steel and reinforced concrete design applied to building structures.

Preference will be given to candidates who served in H.M. Forces during the 1914–18 or 1939–45 wars, provided that such candidates are, or within a reasonable time will be, able to discharge the duties efficiently.

Application forms may be obtained from the SECRETARY, CIVIL SERVICE COMMISSION, Stormont, Belfast, to whom they should be returned, together with copies of two recent testimonials.

*(Continued on next page.)*

## MISCELLANEOUS ADVERTISEMENTS.

(Continued from page lxxiii.)

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Applications are invited for appointment as Lecturer in Civil Engineering at a salary on the scale £650 × £50–£1,350 a year, according to qualifications and experience.

Candidates should have an Honours Degree and practical experience in Public Works Engineering.

Applications (three copies) stating date of birth, qualifications, and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than 31st March, 1956.

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SITUATION WANTED. Energetic representative desires position with progressive company—London and Home Counties. Interested in precast concrete, reinforced concrete and stonework. Experienced in negotiations at all levels, and also administration. Box 4246, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

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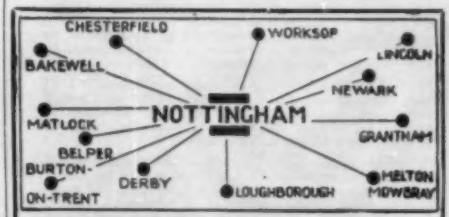


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